

# **The Application Of Insurance As A Risk Management Tool For Alternative Dispute Resolution (ADR) Implementation In Construction Disputes**

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## **ABSTRACT**

### **The Application Of Insurance As A Risk Management Tool For Alternative Dispute Resolution (ADR) Implementation In Construction Disputes**

**Xinyi Song**

In modern days, construction projects have become more and more complex and intriguing. One source of the complexity arises from the large number of parties involved. This is especially the case for large-scale construction projects. Because of such complexity, disputes are almost inevitable and implementation costs associated with dispute resolution have become increasingly expensive. Because most projects operate on tight budgets, cost effective dispute resolution plays an important role in the success of a construction project.

For this purpose, Alternative Dispute Resolution (ADR) techniques such as negotiation, mediation, and arbitration are being widely adopted in large-scale construction projects to resolve disputes in more effective and cost-saving ways. However, the risk of incurring dispute-related cost overruns always exists because of the uncertainty in the distribution of dispute occurrence and the effectiveness of contractually-predetermined ADR techniques. As a result, the traditional self-insured structure which simply retains all dispute resolution costs to the project through contingency fees is no longer considered economical.

While many insurance policies cover the settlement of a dispute, such as professional liability insurance, no specific insurance policy is dedicated to cover the ADR implementation costs such as fees and expenses that are paid to the owner/contractor's employees, lawyers, claims consultants, third party neutrals, and other experts involved in the resolution process. To fill the gap, this dissertation proposes an

insurance model to reduce the potential variations in the dispute resolution budget by pricing ADR techniques as an insurance product. It is designed to transfer the risk of dispute-related cost overruns from the project to a third-party insurance company.

To achieve this goal, this dissertation focuses on three major tasks: 1) investigate the role of ADR implementation insurance in construction risk management, 2) construct a mathematical model to represent the risk attitudes of project participants using utility theory and derive the basic premium of ADR implementation insurance using insurance pricing theory, and 3) develops a comprehensive framework to determine the optimal insurance premium by considering two additional insurance limits - a Deductible Limit (DL) and a Maximum Payment Limit (MPL).

The objective of this dissertation is to provide project participants with an advantageous insurance policy that minimizes their total expected subjective loss. The model can serve as a decision-making support system to help project participants determine whether an ADR implementation insurance policy is attractive for a certain project. To illustrate the benefits of the proposed model, numerical examples are provided for simulation purpose. The results show that ADR implementation insurance, although not a tool to eliminate dispute resolution costs, is a powerful alternative in risk management to transfer the financial implications of ADR implementation risk to a third party.

## Table of Contents

List of Figures.....	iii
List of Tables.....	v
ACKNOWLEDGEMENTS .....	vi
INTRODUCTION .....	1
<b>INTRODUCTION TO MAJOR ADR PROCESSES</b> .....	3
<b>TYPICAL COSTS ASSOCIATED WITH ADR IMPLEMENTATION</b> .....	6
<b>THE HISTORY OF INSURANCE IN THE CONSTRUCTION INDUSTRY</b> .....	10
<b>RESEARCH QUESTIONS AND FORMAT OF DISSERTATION</b> .....	15
APPLYING INSURANCE PRICING THEORY FOR PRICING ADR AS AN INSURANCE PRODUCT .....	18
<b>INTRODUCTION</b> .....	19
<b>PROBLEM STATEMENT</b> .....	22
<b>ADR CONSIDERED AS INSURANCE PRODUCT</b> .....	22
<b>INSURABILITY OF ADR</b> .....	24
<b>INSURANCE PRICING MODEL</b> .....	32
INSURANCE AS A RISK MANAGEMENT TOOL FOR ADR IMPLEMENTATION IN CONSTRUCTION DISPUTES.....	37
<b>INTRODUCTION</b> .....	38
<b>PROBLEM STATEMENT</b> .....	41
<b>UTILITY THEORY AND SUBJECTIVE LOSS FUNCTION</b> .....	42
<b>A SUBJECTIVE LOSS FUNCTION FOR ADR IMPLEMENTATION COSTS</b> .....	46
<b>ADR IMPLEMENTATION INSURANCE MODEL</b> .....	47
<i>Event Tree Analysis</i> .....	47
<i>Total Expected ADR Implementation Costs</i> .....	49
<i>Total Expected Subjective Loss of ADR Cost</i> .....	51
<i>Comparison between Gross Premium and Total Expected Subjective Loss</i> .....	52
<b>ILLUSTRATIVE EXAMPLE</b> .....	52
<b>CONCLUSION</b> .....	56
DETERMINING THE OPTIMAL PREMIUM FOR ADR IMPLEMENTATION INSURANCE IN CONSTRUCTION DISPUTE RESOLUTION.....	58

<b>INTRODUCTION .....</b>	<b>59</b>
<b>PROBLEM STATEMENT .....</b>	<b>61</b>
<b>ADR IMPLEMENTATION INSURANCE MODEL .....</b>	<b>63</b>
<b>ILLUSTRATIVE EXAMPLE .....</b>	<b>66</b>
<b>ANALYSIS OF RESULTS .....</b>	<b>70</b>
<b>MODEL VALIDATION .....</b>	<b>72</b>
<b>CONCLUSIONS .....</b>	<b>74</b>
<b>CONTRIBUTIONS .....</b>	<b>77</b>
<b>ADR INSURANCE FOR DIFFERENT PROJECT PARTICIPANTS.....</b>	<b>78</b>
<b>INDIVIDUAL CONTRIBUTIONS .....</b>	<b>79</b>
<b>LIMITATIONS AND SUGGESTED DIRECTIONS FOR FUTURE RESEARCH.....</b>	<b>83</b>
<i>Limitation 1: Subjective Loss Function .....</i>	<i>83</i>
<i>Limitation 2: the assumption of independence among dispute resolution processes .....</i>	<i>87</i>
<i>Limitation 3: the time value of money .....</i>	<i>88</i>
<i>Limitation 4: application of ADR insurance in industry .....</i>	<i>89</i>
<i>Future Research .....</i>	<i>89</i>
<i>Introduction .....</i>	<i>91</i>
<i>Problem Statement.....</i>	<i>93</i>
<i>The Role Of Insurance In Sustainability Risk Management .....</i>	<i>95</i>
<i>Conclusions .....</i>	<i>99</i>
<b>REFERENCES .....</b>	<b>101</b>
<b>APPENDIX A: Dispute Distribution Simulation In Chapter 2 .....</b>	<b>113</b>
<b>APPENDIX B: Dispute Distribution Simulation In Chapter 3 .....</b>	<b>115</b>
<b>AUTHOR'S BIOGRAPHY .....</b>	<b>118</b>

## List of Figures

Figure 1: ADR Implementation Cost Breakdown .....	6
Figure 2: The Risk Management Matrix.....	10
Figure 3: Typical Insurances on A Construction Project.....	13
Figure 4: An example of Dispute Resolution Ladder (DRL) .....	20
Figure 5: Comparison Of Cash Flows Of ADR Cost In Two Models.....	40
Figure 6: Characteristics of Subjective Loss Function .....	44
Figure 7: The relationship between $GP$ and $E[u(C)]$ .....	46
Figure 8: Analytic Flow Of The ADR Insurance Model .....	47
Figure 9: ETA of ADR Implementation Costs .....	49
Figure 10: Project DRL.....	53
Figure 11: Project ETA Of ADR Cost.....	54
Figure 12: Illustrative Example Of ADR Implementation Costs And Distribution .....	55
Figure 13: Structure of ADR Implementation Insurance.....	61
Figure 14: Schematic Illustration Of The Relationship Between $GP$ And $E[u(C)]$ .....	63
Figure 15: ADR Insurance Model For Determining The Optimal Premium.....	65
Figure 16: Project DRL And Distribution Of Resolution Costs Of Each ADR .....	67
Figure 17: Different Scenarios Of Probability Mass Functions For Project Participants And Insurance Company.....	69
Figure 18: Impacts Of MPL And DL.....	70
Figure 19: Simulation With Different Subjective Loss Functions.....	72
Figure 20: Building A User-Oriented SLF .....	86
Figure 21: Project Management Structure With GHG Emissions .....	95

Figure 22: GHG Emissions Liability Insurance Model .....	99
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## List of Tables

Table 1: The Advantages of ADR Practice.....	4
Table 2: Mediation, Arbitration and Litigation of a Hypothetical \$600,000 Claim by Owner against Architect- Cost Components.....	7
Table 3: Property Insurance And Liability Insurance .....	14
Table 4: Sources Of Conflict And Dispute .....	30
Table 5: Loss Frequency Rating System .....	33
Table 6: General Conflict Exposure .....	34
Table 7: Simulation Results For One Run .....	55
Table 8: Simulation Results .....	56
Table 9: Opportunities To Reduce Emissions .....	96
Table 10: Insurability Of GHG Emissions Liability .....	98

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– Lao-tzu (Chinese philosopher, 571– 471BC)

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# Chapter 1:

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## INTRODUCTION

*"If your only tool is a hammer, then every problem will look like a nail.*

*When it comes to the construction industry, the main dispute resolution tool remains a lawyer, and every disagreement will look like a lawsuit."*

– ENR (1999)

*"Those involved in construction have to cope with so much learning in their own discipline that they shun further involvement in subjects such as insurance and law which in themselves are so deeply and intensely complex. However, insurance and law are interwoven in the basic procedures used in the construction industry to undertake work, be it design or construction or supervision or operation or any combination of the foregoing."*

– Nael G. Bunni (2003)

For as long as the construction industry has existed, clients have misunderstood its ability to deliver problem-free products (Ware 2001). The construction process has several interdependent limits, such as scope, schedule, quality, and cost of work. Moreover, it involves a large number of personnel who work for the independent interests of the owner, contractor, supplier, engineer, etc. Because of the various limits and interests, a construction project is characterized by its inherent nature to foster disagreement and its susceptibility to numerous risks (Michel 1998, Peña-Mora et al. 2003). As a result,

disputes are common and even inevitable in contemporary construction projects. For example, Cheung and Yiu (2006) demonstrated that the likelihood of construction disputes lies in the range of 0.997 to 1.000 for traditional design-build projects in Hong Kong.

The term "claim" and "dispute" are sometimes used interchangeably in the construction industry. In this dissertation, the two are treated differently. Here, a claim is defined by the federal government (1980) as follows:

*"A written demand or written assertion by one of the contracting parties seeking, as a matter of right, the payment of money in sum certain, the adjustment or interpretation of contract terms, or other relief arising under or related to a given contract."*

A claim simply conveys dissatisfaction from one party to another and demands the respondent to react to the claimant's dissatisfaction out of contractual duty (Levin 1998). Not all claims lead to disputes. A dispute only occurs when a claim is rejected by the respondent (Ware 2001). For example, with a delay in construction progress, the owner's request for compensation may or may not constitute a dispute, depending on how the contractor reacts. If the contractor concedes that the delay is the result of inappropriate construction methods, it is a claim. However, if the contractor insists that the owner caused the delay and refuses to compensate for the damage, it is a dispute.

Once a dispute arises, it is in all parties' interests to resolve it in a timely manner. A delay in the resolution of a dispute could have a significant negative impact on the project, especially in a litigious consumer-led environment (Ware 2001). According to Peña-Mora et al. (2003), an average of \$5 billion is spent on construction litigation in the

United States every year and this number is increasing at an average rate of 10% per year. Inefficient dispute resolution not only prevents productive use of project budget, but also lowers work productivity, slows the completion process, impacts the ability to perform under various related contracts, damages long term business relationships and tarnishes the involving parties' reputations (Cushman et al. 2001; Corgan et al. 2002). These intangible costs, though difficult to quantify, may be catastrophic for a project.

Alternative Dispute Resolution (ADR) techniques recognize the need for timely and cost saving dispute resolution and have been widely practiced in the construction industry. This introductory chapter introduces the basic facts of ADR techniques. Later chapters will focus on addressing the risks incurred during the practice of ADR through insurance.

## **INTRODUCTION TO MAJOR ADR PROCESSES**

Over the past two decades, the construction industry has been notorious for creating disputes (Richbell 2008) and well-known for its continuing efforts in developing more efficient methods of dispute resolution (ENR 2000; Hinchey and Schor 2002). A good example is the adoption of ADR techniques to overcome the expensive, ineffective, and often adversarial litigation progress.

The term "Alternative Dispute Resolution" is fairly new and it was not until the 1970s that ADR emerged as a distinct field of study in law (Ware 2001). Generally, ADR refers to a contractual means to resolve disputes without going into the classic courtroom setting (Kovach 2004). It encompasses all legally-permitted processes of dispute resolution other than litigation (Ware 2001). While many procedural aspects of current

ADR work are the result of recent developments, the practice of ADR itself is extremely old. In fact, commercial arbitration agreements took place between ancient Phoenician and Greek traders from 1200-900 B.C. (Ware 2001). Civil arbitrations can also be traced back to ancient times. In the sixth century B.C., arbitrators appointed by the Athenian central government traveled through the countryside to settle disputes between cities (Barrett 2004). Additionally, the ancient civilizations of Assyria, Babylon, China, Egypt, India, and Persia suggested that, while the tendency to solve differences by fighting was rooted deeply in human nature, people also appreciated the benefits of deepened relationships and lasting harmony by settling disputes in more peaceful ways. This search for alternatives to violence gave birth to the precursors of ADR (Barrett 2004; Boulle 2005). Table 1 summarizes some advantages of ADR (Treacy 1995; Levin 1998; Harmon 2003; Richbell 2008).

Table 1: The Advantages of ADR Practice

Speed	<ul style="list-style-type: none"> <li>• No "docket"- a list of cases waiting for trial</li> <li>• Maximum allowable time for each ADR technique</li> <li>• Expedited process solely dependent on the eagerness of the parties to solve the dispute and the complexity of the case</li> </ul>
Economy	<ul style="list-style-type: none"> <li>• Time is money</li> <li>• Costly procedures, such as filing appeals and motions, are eliminated</li> </ul>
Amicable business relationship	<ul style="list-style-type: none"> <li>• Less adversarial atmosphere</li> <li>• Helps preserve positive working relationships</li> </ul>
Impartial neutrals	<ul style="list-style-type: none"> <li>• Knowledgeable expert in the subject matter of dispute</li> <li>• Each party has the right to select an individual as their mediator or arbitrator</li> </ul>
Informality	<ul style="list-style-type: none"> <li>• Conducted in a manner that is more business-like</li> </ul>



	<ul style="list-style-type: none"> <li>• Allows for flexibility in controlling the process by the parties</li> </ul>
Privacy	<ul style="list-style-type: none"> <li>• Not open to public scrutiny</li> <li>• Hearings and awards are kept private and confidential</li> </ul>
Finality	<ul style="list-style-type: none"> <li>• The settlement could be final, binding, and legally enforceable, or advisory only, depending on the predetermined agreement</li> </ul>

Modern forms of ADR include negotiation, conciliation, mediation, arbitration, etc. (Barrett 2004). A few of the more common methods currently used in the construction industry are highlighted below:

- Negotiation: according to Webster's Third New International Dictionary (2002), to negotiate is to "communicate or confer with another to arrive at the settlement of some matter". Negotiation is the most basic form of ADR (Ware 2001).
- Dispute Review Board: a panel of three neutral experts who consider all facts of a dispute and conduct an informal hearing to make recommendations as a basis for further negotiations (Matyas et al. 1996).
- Mediation: "a forum in which an impartial person, the mediator, facilitates communication between parties to promote reconciliation, settlement, or understanding among them" (Texas Civil Practice & Remedies Code §154.023). In construction dispute resolution, the mediator is selected by all parties and is commonly someone knowledgeable in construction and experienced in construction law. The mediator's role is advisory. He or she offers suggestions, but resolution of the dispute rests with the parties themselves. The whole process usually has a time standard (Ware 2001).
- Arbitration: "a forum in which each party and counsel for the party present the position of the party before an impartial third party, who renders a specific award"

(Texas Civil Practice & Remedies Code §154.027). Similar to mediation, parties select the arbitrator who will hear each side of the controversy and render a final decision (Ware 2001). Unlike mediation, arbitration is usually binding<sup>1</sup>.

### TYPICAL COSTS ASSOCIATED WITH ADR IMPLEMENTATION

In dispute resolution, typical ADR implementation costs may include fees and expenses paid to lawyers, accountants, claims consultants, and other experts, as well as salaries and associated overhead of in-house lawyers, company managers, and other employees who must assemble the facts, serve as witnesses, and otherwise process the dispute (Gebken II and Gibson 2006; Menassa 2007). Gebken II and Gibson (2006) further break the cost down for each ADR technique, as shown in Figure 1.

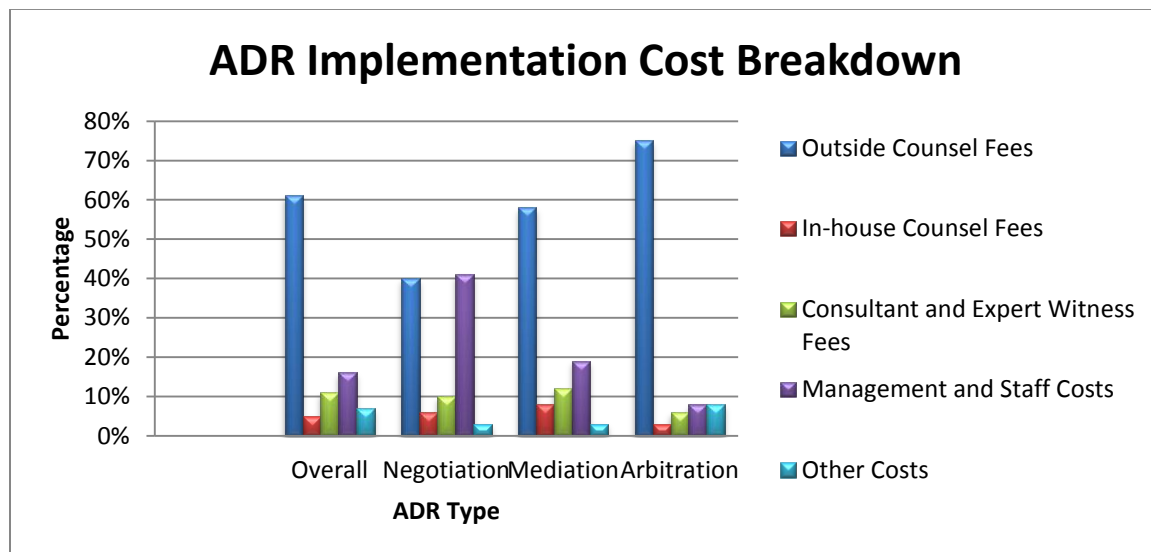


Figure 1: ADR Implementation Cost Breakdown

In the 47 projects collected by Gebken II and Gibson (2006), the overall dispute resolution cost was over \$35 million, which equates to 15% of the settlement/award

<sup>1</sup> In some cases, it is prearranged that the settlement decision will only be advisory and the decision will be reviewed by the courts (Ware 2001).

amounts, 6% of the original claims, and almost 2% of the entire contract amount. It is also important to note the significant impact of selecting different ADR methods on the cost of dispute resolution. Referring to the dispute resolution continuum in chapter 2 (Figure 4), related costs and hostilities of dispute resolution efforts are assumed to escalate from the lower stage of negotiation to the upper stage of arbitration (Menassa 2007). For example, each of the three members of the dispute review board is paid between \$1,000 and \$2,000 to cover expenses of attending meetings and hearing sessions (DRBF 2007); this is compared to \$7,000 to \$8,000 that paid to the arbitrators per day (Zucherman 2007a). Based on 44 projects, Gebken II and Gibson (2006) estimated that the average costs for project disputes that end in negotiation, mediation, or arbitration are \$330,199, \$1,212,433, and \$1,167,182, respectively.

This cost difference between different ADR methods is the result of the component costs (Zucherman 2007b). Zucherman (2007b) detailed representative activities that are involved in mediation, arbitration and litigation for a hypothetical two party ADR processes, as shown in Table 2 (Zucherman 2007b; Menassa 2007).

Table 2: Mediation, Arbitration and Litigation of a Hypothetical \$600,000 Claim by Owner against Architect- Cost Components

<b>Mediation</b>	<b>Arbitration</b>	<b>Litigation</b>
<b>Mediator Compensation</b> 1. Prepare 2. Attend  <b>Mediator's expenses</b>  <b>Owner's attorney Fees</b>	<b>Filing and case service fee</b>  <b>Legal fees</b> 1. fact investigation & preparation of demand 2. AAA (American Arbitration Association) administrative conference 3. one preliminary hearing via telephone 4. Discovery - prepare document request - produce documents	<b>Filing fee</b>  <b>Legal fees</b> 1. Fact investigation and preparation of complaint 2. Case management status conferences with judge 3. Case management order and scheduling conference 4. Discovery -prepare document request -produce

	<ul style="list-style-type: none"> <li>- prepare for 4 depositions</li> <li>- attend depositions (take and defend)</li> <li>- third-party documents discovery</li> <li>- discovery problems</li> </ul> <p>5. Facilitate expert witness investigation, case preparation and report</p> <p>6. Respond to adversary dispositive motion</p> <p>7. Prepare statement of claim</p> <p>8. Final hearings</p> <ul style="list-style-type: none"> <li>- prepare for and attend</li> <li>- prepare post-arbitration brief</li> </ul> <p><b>Legal expenses</b></p> <ol style="list-style-type: none"> <li>1. photocopying</li> <li>2. outside copying of discovery documents</li> <li>3. faxing</li> <li>4. express delivery</li> <li>5. local travel and parking</li> </ol> <p><b>Expert fee-owner transcripts</b></p> <p><b>Arbitrator compensation</b></p> <p><b>Arbitrator expenses</b></p> <p><b>Motion to vacate/defend against such motion</b></p>	<p>documents</p> <ul style="list-style-type: none"> <li>-prepare and respond to interrogatories and requests to admit</li> <li>-prepare for 6 depositions</li> <li>-attend depositions</li> <li>-third-party document discovery</li> <li>-prepare discovery motion</li> </ul> <p>5. defend against discovery motion</p> <p>6. Facilitate expert witness investigation, case preparation and report</p> <p>7. Respond to adversary's dispositive motion</p> <p>8. Prepare pretrial brief</p> <p>9. Prepare pretrial motion in time</p> <p>10. Bench trial</p> <ul style="list-style-type: none"> <li>-prepare for &amp; attend</li> <li>-prepare post-trial brief/findings of fact and conclusions</li> </ul> <p><b>Expert fee-owner Transcripts</b></p> <p><b>Appeal to appellate Court</b></p>
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Based on these activities, the average costs for each ADR implementation process and litigation was estimated as follows: Mediation - \$10,140; Arbitration - \$94,500 plus \$5,000 to \$7000 for submitting a motion to vacate and defend against such a motion; and Litigation - \$120,300 plus \$25,000 to \$35,000 to appeal as per the right to appellate court (Zucherman 2007b).

In addition to the “hard dollar” figures for ADR implementation, there are also indirect costs, as described in the following:

*"The inefficiencies, delays, and loss of quality that disputes cause to the construction process itself, the lost opportunity costs of diverting productive employees away from profit-making activities into litigation support, and the costs of fractured relationships between parties who would otherwise profit if they could continue to do business with each other" (NRC 2007).*

The above discussion demonstrates that both direct and indirect costs of ADR implementation could place a significant amount of huge pressure on an already financially stressed project. This severe financial burden, coupled with a high occurrence frequency of dispute, would increase great risk to the project. To deal with such risk, the risk management matrix (Myhr and Markham 2003) as shown in Figure 2 suggests that the traditional self-insured structure will not work. Instead, the previous discussion concludes that construction dispute resolution is a high expensed event with high frequency. Hence, the best approach is to transfer the risk to a third party, such as an insurance company.

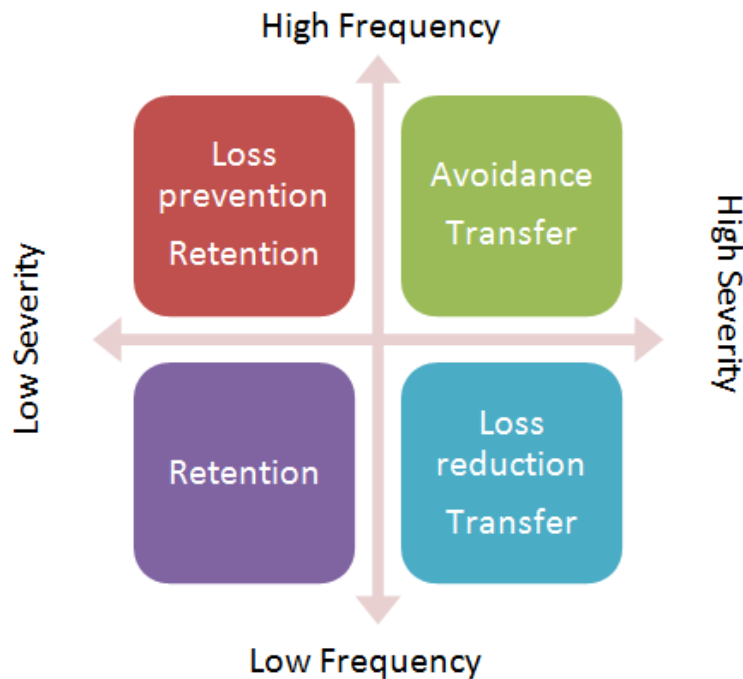


Figure 2: The Risk Management Matrix

## THE HISTORY OF INSURANCE IN THE CONSTRUCTION INDUSTRY

As the second largest industry in the world in terms of assets, the insurance industry has long been in the vanguard of understanding and managing risks. As early as the 2nd and 3rd millennium B.C., Chinese and Babylonian traders distributed their goods to several vessels to minimize risk (Trenerry 2009). The Code of Hammurabi, developed by Babylon's best-known King Hammurabi around 1750 B.C., is the earliest available record that offers rules to discharge loans to traders/sailing merchants if their goods were stolen or lost (Bunni 2003; Vaughan and Vaughan 2007; Trenerry 2009). The modern origins of insurance date back to the advent of marine insurance in the 15th century, which was the result of the expanding world trade on the sea (Palmer et al. 1996). At the time, insurance policies were written to insure against various risks, such as weather-related loss and pirates (Bunni 2003; Gollier 2003). Later, in 1583, as the concept of risk pooling became

universally accepted, life insurance was developed, which was followed by fire insurance after the Great Fire of London in 1666 (Palmer et al. 1996).

Construction insurance, as a branch under accident insurance, did not evolve until the 1930s. However, it quickly thrived after the World War II when the world was focused on rebuilding, which was accompanied by the technology boom in new materials and methods of construction (Bunni 2003). Since then, the construction industry has been in desperate needs for construction insurance. Today, various forms of insurance are provided to deal with different risks associated with a construction project. Traditionally, construction insurance transacts by issuing a number of insurance policies for the benefit of each party involved in a particular project, normally from more than one insurance company (Bunni 2003). In fact, insurance is such an important element of the construction contract that over 10% of the text of the AIA General Conditions of the Contract for Construction is devoted to provide a better understanding of the consolidated principles of risk, responsibility, liability, and indemnity in this area (Bunni 2003, O'Leary 2003).

To understand the insurance aspects and administration of construction contracts, project participants should be reasonably conversant with The AIA General Conditions, Document A201, which specifies basic contract requirements for insurance that must be carried by the owner and contractor in broad general terms under Article 11-Insurance and Bonds (AIA 2007). Specifically, 24 paragraphs cover the contractors' risks, public liability, employer's liability, and professional indemnity insurances (AIA 2007). For example:

*"A201, 11.1 and 11.2: The owner and contractor are both required to carry liability insurance."*

*"A201, 11.4: The owner is also required to carry property insurance."*

*"A201, 11.4.1.2: If the owner decides not to purchase property insurance, the contractor is entitled to purchase it and charge it to the owner. "*

*"A201, 11.3: The owner, optionally, may require the contractor to provide Project Management Protective Liability Insurance. This coverage is in lieu of the owner's and contractor's liability insurance and covers the architect's vicarious liability as well. This insurance will be paid for by the owner. "*

Before beginning a project, both the owner and contractor must provide evidence of required insurance, respectively. Certificates of the contractor's insurance should be addressed to the owner (AIA 2007, A201, 11.1.3). Copies of the owner's property insurance should be addressed to the contractor (AIA 2007, A201, 11.4.6). In addition to these basic policies, other insurance is also required to cover ordinary day-to-day practice and other special activities. It is common to have Supplementary Conditions written in the contract that specify the particular insurance coverage required for the project, interests to be insured, policy limits, perils to be insured, insurance contract term, and deductible amount (O'Leary 2003). For example, marine insurance may be required in international construction (Bunni 2003).



Most construction insurance products currently on the market can be divided into two categories: property insurance and liability insurance (Bunni 2003). Figure 3 shows policies usually issued for each party in connection with construction and Table 3 provides a detailed explanation of these two types of insurance (Bunni 2003).

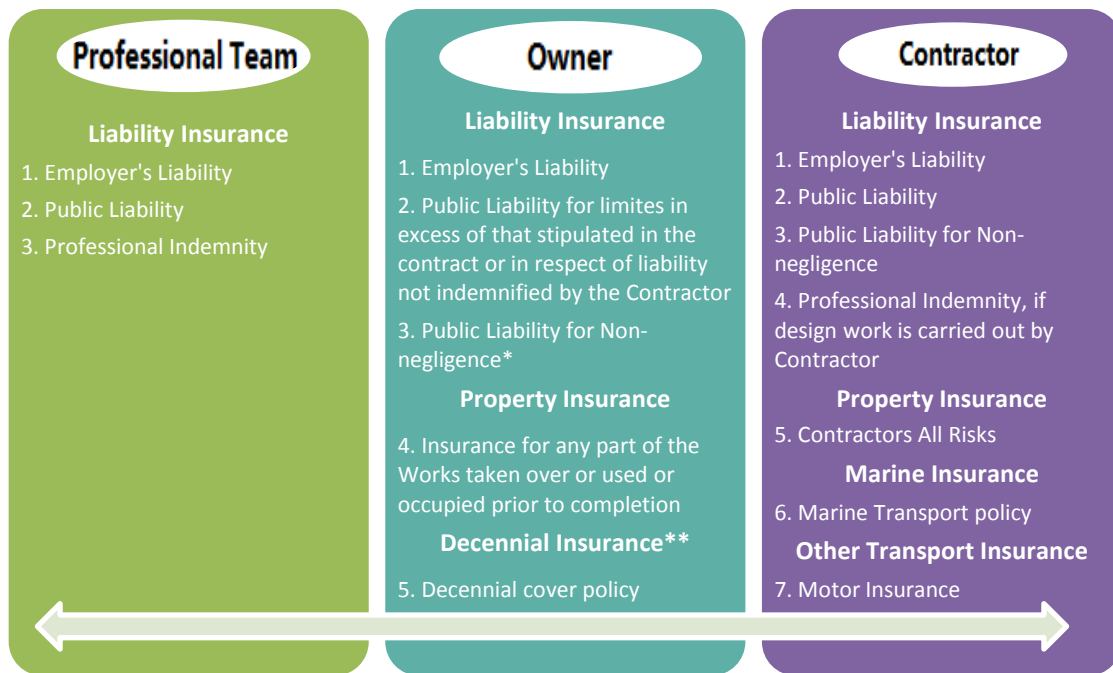


Figure 3: Typical Insurances on A Construction Project

\* If the contractor is found to be non-negligent in respect of damage or loss but instead the owner is found to be responsible and is held strictly liable, then insurance would only apply if the non-negligence element of the risk is specifically included in the cover (Wallace 1995; Bunni 2003).

\*\*Decennial insurance is generally transacted to cover the liability of those involved in construction for latent defects in the stability of the structure and for major defects in the weather shield for ten years (Bunni 2003).

Table 3: Property Insurance And Liability Insurance

Property insurance	Provide protection to the works and any material, equipment and machinery connected with it.	Transacted through: <ul style="list-style-type: none"> <li>Contractors' All Risks Insurance Policy</li> <li>Erection All Risks Insurance Policy</li> </ul>
Liability insurance	Provide protection to the insured party against specific legal liabilities to which he may become exposed as a result of activities culminating in bodily injury and/or property damage.	Transacted through: <ul style="list-style-type: none"> <li>Employers' Liability: towards employees</li> <li>Public Liability: towards third parties who are not partly to the insurance contract</li> <li>Professional Indemnity Insurance: towards the design professional</li> </ul>

Because of tough market conditions, the insurance industry continues to offer competitive insurance products and innovative programs specifically for different situations. However, gaps in insurance coverage always exist. Bunni (2003) offered a list of possible gaps:

- Gaps through uninsurable risks
- Gaps because of a lack of cover, either in the insurance practice or through the wish of the insured
- Gaps because of the use of a conventional method of providing insurance.

The lack of dispute resolution associated with risk coverage falls into a third category "the use of the conventional method of providing insurance." The traditional "wait-and-see" model of self-financing dispute resolution costs is structured like a self-insurance program: project participants normally set aside a certain amount of money, in most cases as part of the contingency fee, to deal with potential disputes. However, it is difficult to predict the frequency and severity of disputes at the beginning of a project; therefore, difficult to predict the likelihood and magnitude of incurring ADR costs when determine

the amount of contingency fee. Numerous factors affect the occurrence of disputes. According to Peña-Mora et al. (2003), the possibility of dispute occurrence varies with the project characteristics. Specifically, there are 25 potential sources of dispute in construction projects, from organizational issues to external and internal issues. Thus, even with a well-organized and well-managed project, the contractual ADR may not always be the best method to resolve all types of disputes. In addition, disputes can escalate and there is always the chance of incurring an unexpected high ADR cost. To understand how ADR implantation insurance works, I draw an analogy from the health insurance industry. In health insurance, there is no guarantee that a person will not have a serious accident or illness during a certain period of time even he/she appears to be very healthy. Also, minor symptoms could lead to severe medical condition if not treated properly. Therefore, people choose to manage this risk by purchasing health insurance, thereby transferring the risk of incurring high medical expenses to the insurance company.

## **RESEARCH QUESTIONS AND FORMAT OF DISSERTATION**

The research has two objectives and the related questions investigated are as follows:

- First objective: Determine the feasibility of an ADR implementation insurance policy.
  - 1) What is the role of insurance as a risk management tool in construction dispute resolution?
  - 2) How should one calculate gross premium for a loss exposure?
  - 3) How can one capture risk attitudes toward an uncertain ADR cost of project participants?

- 4) What is the maximum premium that risk-averse project participants are willing to pay?
- Second objective: Determine the optimal insurance premium for project participants.
- 5) What is the distribution of ADR costs for a certain project?
- 6) What is the total expected loss for project participants with and without insurance?
- 7) What is the total expected subjective loss for project participants with and without insurance?
- 8) What is the total expected loss for the insurance company?

This dissertation follows a three-paper format. Each paper builds on the previous to establish an advanced model. The first paper (Chapter 2) investigates the role of ADR implementation insurance in construction risk management and explores the possibility of pricing ADR techniques as an insurance product. By drawing on the analogy from commercial insurance products such as health insurance, it proposes a mathematical way to determine the basic premium of ADR implementation insurance using the pure premium method adopted from insurance pricing theory.

The second paper (Chapter 3) builds on the first paper and develops a mathematical model that captures the risk attitudes of project participants using utility theory. This model incorporates uncertainties in potential ADR implementation costs using Event Tree Analysis (ETA) and Poisson Process simulation, which will allow one to calculate the insurance premium and compare the premium with project participants' subjective loss. This analysis will serve as a decision-making support system to

determine whether an ADR implementation insurance policy is attractive for a certain project.

Building on the model developed in the second paper, the third paper (Chapter 4) considers two additional insurance limits - a Deductible Limit (DL) and a Maximum Payment Limit (MPL) to screen out moral and morale hazards, which are the two most common risks that prevent effective use of insurance. As a result of these three papers, a comprehensive framework will be developed to determine the optimal premium for ADR implementation insurance. The main goal of this dissertation is to provide a mutually advantageous insurance policy and minimize project participants' total expected subjective loss.

Chapter 5 summarizes the contributions of the research to our current understanding of financial risk management in construction dispute resolution. Chapter 6 discusses the limitations of the research and I suggest potential streams for future research. Finally, a reference section is provided for a bibliographic list of the publications used in the dissertation.

## Chapter 2

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### **APPLYING INSURANCE PRICING THEORY FOR PRICING ADR AS AN INSURANCE PRODUCT<sup>2</sup>**

#### **ABSTRACT**

As litigation is recognized as a costly and time-consuming method to resolve disputes, Alternative Dispute Resolution (ADR) techniques are being adopted in construction projects to help handle disputes in a more effective way. However, there are potential costs related to ADR implementation as it requires expenditures to cover the expenses incurred by the owner's/contractor's employees and third party neutrals. Normally those costs are determined during the project planning phase prior to the actual occurrence of disputes. In this study, the possibility of pricing ADR as an insurance product will be explored. It is similar to the concept of "premium" in insurance industry. The objective is to provide project participants with an economic advantage by investing a certain amount of premium in the beginning of the project in exchange for compensation from the insurance company in the uncertain event of an unknown ADR costs that may be incurred during the construction phase. Insurance pricing theory's underwriting concepts is utilized to develop similar concepts in ADR pricing. A conceptual model is presented to perform the ratemaking process by drawing an analogy from health insurance. An

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<sup>2</sup> This paper was co-authored with Carol Menassa, Feniosky Peña-Mora, and Robert F. Conger. It was published in the ASCE Construction Research Congress 2009: Building a Sustainable Future. The citation is as follows:

Song, X., Menassa, C., Peña Mora, F. and Conger, F.R. (2009). "Applying Insurance Pricing Models for Pricing Alternative Dispute Resolution as an Insurance Product." *Proceedings of 2009 Construction Research Congress (CRC)*, ASCE, Seattle, Washington.

numerical example of a construction project is used to illustrate the mathematical calculations required to determine the premium of the proposed ADR techniques.

## **INTRODUCTION**

The construction industry in the United States plays a powerful role in sustaining economic growth. It provides job opportunities for 7.6 million people, more than 5% of the total nonfarm workforce and makes a large contribution to the gross domestic product (GDP), totaling \$1.2 trillion or 9% of GDP in 2006 (AGC 2008). The intricacy and magnitude of the construction work often result in complex contract documents, which furthermore lead to complex disputes (Harmon 2003). In the construction industry, disputes are almost inevitable in each and every project due to poorly prepared and/or executed contract documents, inadequate planning, financial issues, and communication problems, etc. (Harmon 2003). The increasingly costly and time consuming court proceedings (Treacy 1995) indicate a great need in the construction industry to find a more effective method to resolve disputes.

Alternative Dispute Resolution (ADR) is a general term for a number of methods by which disputes are resolved privately other than through litigation in the public courts (Kovach 2004). A Dispute Resolution Ladder (DRL) was proposed by Findley (1997) where a broad spectrum of ADR techniques is organized in a stepped manner. The example showed in Figure 4 includes six steps from the lower stage of prevention, negotiation, to middle stage of standing neutral, non binding, and finally to the upper stage of binding resolution and litigation (USACE 1989; Caltrans 2000; Peña-Mora et al. 2003).

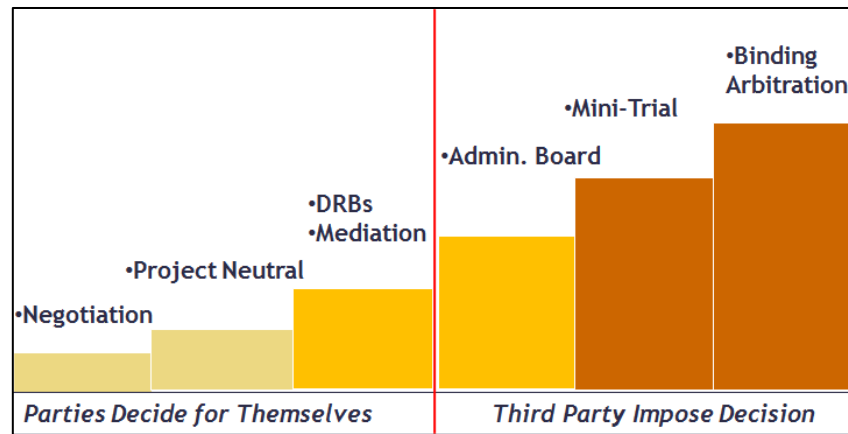


Figure 4: An example of Dispute Resolution Ladder (DRL)

When disputes escalate from lower stage to upper stage, the expenses and hostility also increase (Peña Mora et al. 2003). Compared to the general dissatisfaction with litigation, the implementation of ADR has proven to be faster, more effective, less formalistic, cheaper and often less adversarial (Treacy 1995). Questionnaire results in a study by Chau (2007) show that the top two reasons for project participants in Hong Kong to experiment with mediation or adjudication in construction disputes are "time and cost savings and desirability to continue amicable business relationship."

As mentioned above, ADR techniques are used to overcome the ineffectiveness of litigation in providing a fast and amicable settlement of construction disputes. However, it is not without costs. Neither time nor money is infinite and the implementation of ADR requires a certain amount of each, from both the owner's/contractor's employee and third party neutrals (Menassa 2007). According to Gebken II and Gibson (2006), while engaging in litigation is often more costly, resolving a dispute in the construction industry is an expensive endeavor no matter which dispute resolution methodology is selected. Moreover, although ADR techniques are implemented when disputes arise during the construction phase, the decision about the budget account for management and staff time



spent on dispute resolution is usually undertaken during the project planning phase. Thus, people who make managerial decisions of investing in an ADR technique in exchange for the perceived savings in the project face the uncertainty of the exact amount of ADR cost in the future. Also, a contractually-agreed dispute resolution methodology may not be the best one once disputes have arisen (Harmon 2003). If this is the case, the project will incur an even higher cost to adapt new approaches in the dispute resolution process. Given that most construction projects operate on tight budgets, how to transfer this uncertainty of an unknown potential ADR cost to a third party is the question this paper will address.

In the insurance industry, the uncertainty about whether a particular loss will occur is referred to as a risk. To reduce their risks, businesses and individuals transfer the potential financial consequences of their loss exposure to an insurer by purchasing an insurance product (Myhr and Markham 2003). For example, people purchase health insurance to cover medical costs they might incur in the future. The risk transfer process does not eliminate the possibility that a loss will occur, but it does reimburse the costs associated with that loss. In return for this transfer, an insurer receives a premium (Myhr and Markham 2003). In the construction industry, because of the uncertainty of the frequency and magnitude of disputes and the potential disruption they could cause to the project, it would be important to think about the possibility of pricing dispute resolution methods---ADR techniques as an insurance product and transferring the uncertain potential cost of ADR implementation to a third party by paying a certain amount of premium at the project planning phase and throughout the project.

## **PROBLEM STATEMENT**

In applying the basic concepts of risk management and insurance pricing models to an ADR pricing model, this paper will focus on the following questions, while being mindful of the overriding objective of promoting ADR techniques in the most possible effective and cost saving manner.

1. Why it is useful to consider pricing ADR techniques as an insurance product?
2. How can ADR be priced as an insurance product?

An analogy between general insurance products and ADR techniques may prove to be an answer to the first question and an ADR pricing model based on the insurance pricing model will be proposed later.

## **ADR CONSIDERED AS INSURANCE PRODUCT**

In risk management process in the insurance industry, insurance products have served as both risk control and risk financing techniques. The first function is designed to eliminate or reduce the likelihood or amount of loss (Myhr and Markman 2003). For example, as part of most health insurance plans, routine visits to a doctor's office or periodic physicals provide ways to reduce the likelihood of getting sick. Similarly, keeping ADR experts on the project can help identify potential conflict items before the actual occurrence of disputes and thus provide opportunities for preventing these issues from becoming the basis of a future dispute (Gebken II and Gibson 2006). Moreover, even if disputes do occur, consultants and experts who have close association with the project would be able to quickly identify conflict resources and help keep the dispute resolution

process on the lower, less contentious and less costly stages of the dispute resolution ladder.

On the other hand, as a risk financing technique, an insurance product also provides a mean to pay for losses that do occur (Myhr and Markman 2003). Again, taking health insurance as an example, the insurance company will compensate customers for their medical expenses wholly or partially, in return for payment of a specified premium. In dispute resolution, typical ADR implementation cost may include fees and expenses paid to lawyers, accountants, claims consultants and other experts; salaries and associated overhead of in-house lawyers, company managers, and other employees who have to assemble the facts, serve as witnesses and otherwise process the dispute, etc. (Gebken II and Gibson 2006). If ADR techniques can be priced as insurance products, project participants could expect to substitute a certain expense—the premium—for a potential unknown ADR implementation cost.

In addition, we see the potential for cost savings by applying the insurance concept of In-Network/Out-of-Network Coverage to ADR implementation. Outside counsel fees account for over 62 percent of the entire transactional cost in dispute resolution and are larger than the next most costly subcategory by almost four times (Gebken II and Gibson 2006). In health insurance, coverage and cost saving are greatest when an in-network medical care provider is chosen. In the same way, parties involved in construction disputes could seek outside counsel within a network pre-agreed with the insurance company and realize project savings.

## **INSURABILITY OF ADR**

Not all risks are insurable by private insurers (Pritchett et al. 1996). A risk that is perfectly suited for insurance would meet six ideal requisites: it must have a large number of similar exposure units; the claims must derive from a fortuitous loss outside the control of the principal; the losses should be definite; it must have a determinable probability distribution; it must be catastrophe unlikely, and last, it must have economic feasibility (Pritchett et al. 1996).

For the first requirement, according to law of large numbers (Tijms 2007), as a sample of observations is increased in size, the relative variation about the mean declines. Because insurance premium rates are based on predictions of the future which are expressed quantitatively as expected losses, expected losses must be calculable within a reasonable degree of accuracy (Pritchett et al. 1996). If there are significant numbers of projects to be insured which require similar dispute resolution processes, then the average number and cost of dispute occurrence can be more accurately predicted for the universe of upcoming projects by analyzing and modeling statistical data on similar projects and past experience, even though the number and cost of disputes on a single project are not susceptible to forecast.

Regarding the second requirement, fortuitous means the risk assumed by an insurer must involve only the possibility, not the certainty, of loss to the insured; and that the insured will not cause the loss to occur nor dictate the amount of its cost (Pritchett et al. 1996). For ADR implementation, although potential disputes occurrence arise from many factors, project participants do have a great deal of influence on the occurrence and resolution of a dispute. Thus, this characteristic of ADR creates some potential moral

hazard, which the insurance company will seek means to manage and control. However, this “non-fortuitous” aspect of ADR actually addresses another important potential function of insurance: to prevent potential losses. Similar to periodic physicals in health insurance, the availability of ADR insurance offers the opportunity for the insurer to provide value-added services, or require the use of protocols that are intended to improve project management and project communication processes, and therefore reduce the likelihood of a dispute occurring in the first place.

The third requirement means loss must be definite in time, place, and amount (Pritchett et al. 1996). In a construction project, there will be detailed contract provisions regarding recordkeeping and resolution processes for construction disputes, and in a DRL there will be very specific time and cost limits for each step of the ladder.

For the fifth requirements, loss exposure in dispute resolution (ADR implementation cost) might be significant, but rarely “catastrophic” in nature. Catastrophic in this context refers to an event that would affect many insureds at the same time. For example, hurricanes or earthquakes in homeowners insurance are considered as catastrophes because thousands of homes may be destroyed by a single event. However, an economic downturn might cause a lot of disputes in the construction industry. As Jennifer Hicks (2008) said in “A look ahead at 2009”: “The world faces extraordinary economic times and the global credit crisis has caused delays or the suspension of many projects”. Usually in cases of exposure to catastrophes insurance companies use reinsurance (“insurance for insurance companies”) to protect themselves against losses in cases beyond their retention limit per catastrophe (Pritchett et al. 1996).

As to the last requirement, for insurance to be economic feasible, in other word, to make the purchasing of insurance practical, the size of possible loss must be significant to the insured and the cost of insurance must be small compared with the potential loss (Pritchett et al. 1996). The negative impact of disputes to construction projects has been discussed at the beginning of this paper; Moreover, because of the uncertainty of frequency and severity of dispute occurrence, the cost of insurance is generally small compared to the potential ADR implementation cost. The detail will be explained later.

To sum up, ADR implementation cost, based on a reasonable fit to these six characteristics, generally meets the requisites for insurability. In another word, ADR could be insurable in the private market.

## **INSURANCE PRICING THEORY**

The pricing methodology used in insurance industry depends significantly on the variable (product, person, organization and activity) to be priced and the statistical data available (Myhr and Markman 2003). However, the basic principles of pricing methods are common across many types of insurance. The process of determining what loss exposure will be insured, for what amount of insurance, at what price, and under what conditions is called underwriting (Myhr and Markman 2003). Underwriting is common in all forms of insurance (Merlis 2005). For example, medical insurers will charge higher premiums to old people who have a smoking habit; property insurers may offer reduced premiums for safety features such as smoke detectors.

In insurance pricing, ratemaking refers to the process by which an insurance company calculates the price it seeks to charge its customers for the insurance it provides (BISHCA 2008). The ratemaking process is challenging because the amounts of

fortuitous future loss and their associated expenses are unknown when the insurance prices are developed at the beginning of an insurance contract period (Myhr and Markman 2003).

ADR pricing, analogously to insurance pricing, should take into account of the amount needed to pay potential ADR costs, and expenses as well as the targeted profits by the insurance company (which, if achieved, compensates the capital invested by the insurer in support of the process and the risk of uncertain financial outcomes that is shouldered by the insurer).

There are three categories of ratemaking methods insurers commonly use for insurance products such as medical insurance or property/casualty insurance that we have been examining as analogies for ADR: pure premium methods; loss ratio methods; and judgment methods (Myhr and Markman 2003). Pure premium methods are used to develop rates from past claims experience; loss ratio methods are used for modifying existing rates; judgment methods rely heavily on the experience and knowledge of an actuary (Myhr and Markman 2003). This paper will use a pure premium method to illustrate how one might calculate premium rates for an insurance-like approach to funding ADR in the construction industry.

Pure premium methods calculate indicated insurance rates using estimates of future claims and expenses, typically based on an examination of historical claims and expense experience, and also include a profit loading factor (Myhr and Markman 2003). The following formula uses several terms of art (Myhr and Markman 2003): Exposure units are the persons or items of property that are insured for a specified period of time; Pure premium means the amount included in the rate per exposure unit required to pay

claims; Expense loadings include the insurer's acquisition and operating expenses plus premium tax and possibly loss adjustment expenses (i.e., the administrative costs of handling claims), as well as a provision for profit; Gross premium is the final premium indicated to be paid to the insurance company and equals to Pure premium plus Expense loading.

In pure premium methods,

$$\text{Gross Premium} = \text{Pure Premium} / (1 - \text{Expense Loading Factor}) \quad \text{Eq. (2.1)}$$

Where,

$$\text{Pure Premium} = \text{Loss Frequency} \times \text{Loss Severity} \quad \text{Eq. (2.2)}$$

and where loss frequency is the average number of claims per exposure unit, and loss severity is the average cost incurred per claim. Because insurance is a mechanism of sharing, or averaging, financial risk across a population of insured, these concepts specifically do not imply that each insured has, or is expected to have, the same number of claims per year, or that all claims involve similar costs.

## **AN ANALOGY BETWEEN HEALTH INSURANCE & ADR TECHNIQUES**

To explain more clearly how to apply this formula to calculate the premium of ADR techniques, the process of ratemaking in health insurance is used as an analogy in this paper. There are several parallels between health insurance and ADR. First, both deal with unique objects. In health insurance, the exposure unit is individual human beings while ADR deals with individual projects. The ratemaking process in health insurance considers each customer's unique features such as age, gender and life style, etc. Similarly, the likelihood, nature and cost of disputes in construction projects is influenced by each project's unique features such as site condition, contract type and construction



methods. The types of disputes that may arise, in turn would affect the implementation of ADRs. Second, both health insurance and ADR reflect various methods for addressing the underlying issue. In health insurance, there are many choices to deal with sickness, such as taking medicine, visiting a doctor's office, or visiting a hospital, and the related outcomes and medical cost may be different depending on which method the customer chooses. Similarly, in dispute resolution there are many combinations of ADR methods. Third, the results of health care, like ADR, are not guaranteed. In health insurance, despite the measurements taken and medical expense incurred, the insurer does not guarantee to completely cure the disease. Likewise, using ADR techniques does not guarantee a satisfied settlement of disputes. The implementation might escalate to litigation eventually.

Basically, health insurance provides protection against the possibility of financial loss due to health care use (Fernandez 2005). The insurance company obtains information on an applicant's current health status, medical history, and other indicators of potential future costs. Then it estimates the overall risk of healthcare expenses and develops a routine finance structure such as a monthly premium (Claxton 2008). In the ratemaking process, pure premium refers to the total amount of financial obligation due to injury and illness that the insured is expected to incur over a certain period (Chen 2004). The pure premium can be separated into two aspects: frequency and severity. Frequency is how often a loss occurs during a defined time period; Severity is the average amount of loss (Chen 2004). In a construction project, if considering the use of ADR as analogous to an insurance claim (as ADR costs both time and money), then loss frequency is analogous to the possibility of dispute occurrence, which is also the possibility of ADR being utilized.

In health insurance, loss frequency is related to each customer's unique features such as age, gender, life style, etc., and can be estimated once the insurer knows those characteristics of the insured. In construction projects, the possibility of disputes occurring and ADR being applied varies with the project characteristics, and can be estimated by knowing those characteristics of a particular project (Peña-Mora et al. 2003). Table 4 illustrates twenty-five potential sources of disputes in construction projects (adopted from Peña-Mora et al. 2003):

Table 4: Sources Of Conflict And Dispute

Area	Discipline	Sources of Dispute
Organizational issues	Structure	Internal/ external organizational structure, delivery systems, inappropriate contract type, contract documents, contract terms, and law
	Process	Performance, quality, tendering pressures, payment, delays, disruption, acceleration, administration, formal communication channels, information sharing, reports, and poor communication
	People	Misunderstanding, unrealistic expectations, culture, language, communications, incompatible objectives, management, negligence, work habits, and lack of team spirit
Uncertainty	External	Change, variations, environmental concerns, social impacts, economics, political risks, weather, regulations, uncertainty, and unpredictability
	Internal	Incomplete scope definition, errors in design, unforeseen site conditions, construction methods, and workmanship

Based on past experience and statistical data, project participants should be able to identify and weight the possible indicators of dispute occurrence from the above categories. For example, an international design-build commercial building project may have higher likelihood of disputes arising from problems in communication channels (i.e., organizational-process) and changing political environment (i.e., uncertainty-external). In the model explained later, each identified source will be given a weight to show its anticipated impact on the probability of dispute occurrence.

In health insurance, loss severity, or the estimated medical cost is influenced by the kind of medical service the customer is likely to seek, such as visiting a doctor's office or hospital. Different medical services result in different costs. For example, average expense per outpatient visit and average expense per hospital stay are significantly different. Similarly, the estimated cost for ADR implementation is determined by the different combinations of ADR techniques (such as DRLs) the project participants decide to incorporate into the contract documents, the likelihood of the different techniques being used, and the effectiveness and cost of these techniques. For example, in an airport project, the project participants decide to implement a DRL which goes through an Architect/Engineer or Supervising Officer to mediation, then arbitration if the first two fail to provide a satisfactory settlement. Then the "loss severity" can be calculated as the product of the daily expense and the estimated days for dispute resolution. Normally there is a time limit before parties escalate the dispute to the next stage. Moreover, in health insurance, the medical service the customer first seeks might not guarantee to cure the disease. For example, patients infected with an influenza that cannot be cured in a clinic may later be hospitalized. In dispute resolution, the first step of the contractual DRL might not achieve a satisfactory settlement. Thus, the ADR cost may escalate as the resolution process is brought to a higher stage. This further illustrates the merits of considering managing ADR techniques through an insurance product that transfers some of the risk to the insurance company.

## INSURANCE PRICING MODEL

The application of the insurance pure premium pricing model to ADR is illustrated in this section through two simplified examples. The figures used in the examples are totally hypothetical, significantly over-simplified and are only used for explanation.

Assume that Mike wants to purchase private health insurance for himself. The insurer, based on Mike's characteristics (40-year old, male, using tobacco regularly), estimates that he has a 10% chance of becoming severely ill during a policy period of one year. Based on past experience of similar people, the insurer estimates that the average healthcare expenses per illness will be \$10,000. In this case, the estimated Loss Frequency (*LF*) for insureds similar to Mike is 10%; Loss Severity (*LS*) is \$10,000. Thus according to Equation (2.2), the estimated Pure Premium (*PP*) is:  $\$10,000 \times 10\% = \$1,000$ . For our representative health insurance company, add an Expense Loading Factor (*ELF*) of 20% to cover the expenses and the target profits<sup>3</sup>. Then according to Equation (2.1), the indicated Gross Premium (*GP*) is:  $\$1,000 / (1 - 0.20) = \$1,000 / 0.80 = \$1,250$ . Thus, \$1,250 is the premium the insurance company calculates to be an appropriate price for Mike to pay for his health insurance<sup>4</sup>.

In ADR for construction projects, the ratemaking process could be similar. For example, a homebuilder is considering constructing three new houses in a local subdivision. Assume that we have identified four sources of conflicts and evaluated them using a 0~1 rating system as shown in Table 2.2 (adapted from Peñã-Mora et al. 2003) to

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<sup>3</sup> Most companies assign all expenses in proportion to loss costs (Schirmacher and Feldblum 2006). The percentage varies among different business lines. For example, the average ELF for auto insurance is 24.7% (Schirmacher and Feldblum 2006), while for worker's compensation it is around 23% (CBS 2010).

<sup>4</sup> The actual price charged for insurance may, and often does differ from the indicated price due, for example, to competitive pressures in the marketplace, legal and regulatory constraints, insurer objectives of growth and customer retention. And, the customer may choose not to pay the price quoted by the insurance company, instead choosing different coverage, a different insurance company, or no insurance at all.

weight the loss frequency based on the past experience of this builder, the past experience of other builders, and the project characteristics. Here, Loss Frequency refers to the probability of dispute occurrence  $P(c)$  during the project. (The use of a maximum value of 1.0 in Table 5 corresponds to the highest frequency dispute type occurs on average per contract period.)

Table 5: Loss Frequency Rating System

Very low	Low	Medium-Low	Medium	Medium-High	High	Very high
$\approx 0$	0.1	0.25	0.5	0.75	0.9	$\approx 1$

Assume that the builder is considering including a DRL in the contract document. In this DRL, once the dispute occurs, it goes through Architect/Engineer or Supervising Officer (ADR1) to mediation (ADR2), then arbitration (ADR3) if the first two fail to provide a satisfactory settlement. Then the “loss severity” is the product of the daily expense and the estimated days for dispute resolution. More specifically, when the dispute resolution process starts, the dispute is first turned to Architect/Engineer or Supervising Officer. To cover this expense, assume for this illustrative calculation that the unit cost is \$500 per day for this step. If the initial attempt fails to achieve the settlement within the maximum allowable time, the dispute escalates to the next level with mediation between the owner and contractor representative; assume the cost at this level also is at a unit cost of \$500 per day. Additionally, if the dispute is not resolved at the previous levels, it is turned to the final step of arbitration. Assume for this illustration that the cost at this level is \$1000 per day. The builder then evaluates the impact of each source of conflict based the estimated duration of each dispute resolution process. As the builder lists various sources of conflicts and relates the probability that they will occur and the impact of each, he/ she develops a combined risk exposure table like Table 6.

Table 6: General Conflict Exposure

Sources of Conflicts	Probability of Occurrence P(c <sub>i</sub> )	Duration of dispute resolution process (days)			Expected total cost of ADR implementation i(c <sub>i</sub> )
		ADR1	ADR2	ADR3	
Miscommunication	High (0.9)	20	-	-	\$10,000
Performance/ Quality	High (0.9)	20	20	-	\$20,000
Management	Med (0.5)	30	20	-	\$25,000
Contract type	Low (0.1)	30	20	20	\$45,000

From this analysis, the builder and the insurance company are able to get a sense about the level for the estimated premium. According to Equation (2.2), the estimated pure premium (PP) is:

$$\begin{aligned}
 PP &= \sum_{i=1}^4 P(c_i) \times i(c_i) = 0.9 \times 10,000 + 0.9 \times 20,000 + 0.5 \times 25,000 + 0.1 \times 45,000 \\
 &= \$44,000
 \end{aligned}$$

Add an Expense Loading Factor (*ELF*) of 20% (illustrative value, assumed for this example) to cover the expenses and the target profits of the insurance company, and then according to Equation (2.1), the Gross Premium (*GP*) should be: \$44,000/(1– 0.20) = \$44,000/0.80= \$55,000. Thus, \$55,000 is the indicated premium for the builder needed to pay the insurance company for his ADR implementation insurance. (As noted earlier, actual premiums in the marketplace may vary.)

## CONCLUSION

The objective of this paper was to explore the possibility of transferring the potential cost of construction project ADR implementation to a third party. It appears that there are both risk management and risk financing benefits potentially available to builders if such a process can be devised. The risk is susceptible to analytical risk transfer pricing

techniques similar to those used in pricing traditional insurance coverages such as health insurance, specifically pure premium methodologies. Given the relatively simple example, the model proposed in this paper is by no means an encompassing system for ADR pricing. While the approach illustrated in this paper is easy to understand and apply, it is likely that much more sophisticated pricing structures will be needed in practice to reflect the wide variations of construction projects, parties, disputes, and the dispute resolution processes.

For future research, more data must be collected regarding construction projects, and dispute resolution, particular the frequency and cost of relevant events. Additional data will allow for analyses that are more detailed and relevant, while remaining practical. In addition, future research should attempt to perfect the model in a more systematical way. While this paper provided a framework of the pricing method, the details of how to use it directly in a construction project still need more work.

To next generation of pricing model for ADR might contain four modules: Information, Modeling, Results and Decision. Information includes the input of exposure data such as project location, engineering characteristics, contract type, etc. and policy information such as coverage value, deductible, limits. Then all the information will go through the Modeling process producing the Results of indicated Gross Premium. Finally, the calculated Gross Premium enters a decision making module in which the participants may consider the marketplace conditions regarding actual premiums, the effects of any risk management programs on the dispute frequency or cost, and the other financing alternatives available to the participants. If the marketplace allows for a fair profit, the insurance company may be willing to sell the product in the marketplace. If the risk

transfer allows for a useful reduction of the builder's risk and the marketplace allows for a reasonable premium level, the builder may also be interested in paying a premium to transfer that risk to an insurer.



## Chapter 3

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### **INSURANCE AS A RISK MANAGEMENT TOOL FOR ADR IMPLEMENTATION IN CONSTRUCTION DISPUTES<sup>5</sup>**

#### **ABSTRACT**

Nowadays, along with the inherent intricacy and magnitude of large-scale construction projects come increasingly complex disputes. Because most projects operate on tight budgets, alternative dispute-resolution (ADR) techniques such as negotiation, mediation, and arbitration are being widely adopted in large-scale construction projects to help handle disputes in more effective and cost-saving ways. However, the risk of incurring uncertain ADR-implementation costs in the dispute-resolution process has become an important issue. The traditional self-insured approach of simply retaining all risks is no longer considered economical. One way to reduce the potential for variations in the dispute-resolution budget is to price ADR techniques as an insurance product, which allows project participants to transfer the risk of incurring unexpectedly high ADR implementation costs to the insurance company. Despite this advantage, many factors are preventing project participants from investing in ADR implementation insurance. This paper proposes a model on how to use ADR implementation insurance as a risk management tool for construction dispute resolution. It first investigates the possibility of using insurance for ADR-implementation and then uses subjective loss to represent the

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risk-averse attitude of project participants and quantify the effect of ADR implementation costs in monetary terms. Event-tree analysis (ETA) is used to simulate different dispute-resolution processes and determine the probability mass function of ADR implementation costs by drawing analogies from seismic risk insurance. These probabilities are employed to calculate the expected ADR implementation costs and to derive the insurance premium. Finally, the gross premium is compared to project participants' subjective loss to help them determine whether purchasing ADR implementation insurance is necessary. At the end, a numerical example is presented to illustrate the application of the methodology.

## **INTRODUCTION**

In recent years, because of the inherent intricacy and magnitude of large-scale construction projects, construction disputes are nearly inevitable and increasingly complex (Harmon 2003). Since court proceedings are extremely costly, time-consuming and generally considered ineffective in construction dispute resolution, most construction contracts now contain some provision for Alternative Dispute Resolution (ADR), which is the most generally acceptable contractual means to resolve disputes without going into litigation (Kovach 2004). Common ADR methods include negotiation, Dispute Review Board (DRB), mediation and arbitration (Peña-Mora et al. 2003). Often, a Dispute Resolution Ladder (DRL) is proposed in the contract for ADR implementation where multiple ADR techniques are organized in a stepped manner (USACE 1989, Caltrans 2000, Peña-Mora et al. 2003). When disputes escalate from a lower stage of prevention to an upper stage of arbitration or litigation, the expenses and antagonism also increase (Peña-Mora et al. 2003, Menassa and Peña-Mora 2007). Typical ADR implementation costs may include fees and expenses paid to the owner's/contractor's employees, lawyers,

claims consultants, third party neutrals, and other experts associated with the resolution process (Gebken II and Gibson 2006, Menassa and Peña-Mora 2009).

Although ADR is recognized as a more effective and less adversarial technique over litigation in construction dispute resolution (Treacy 1995), project participants face uncertainty about future ADR implementation costs, as the number of disputes and the amount of ADR implementation costs in each dispute will not be known until the actual occurrence of disputes during the construction phase. In the traditional “wait-and-see” model, in which the ADR implementation costs are self-financed from the project’s own fund, this uncertainty prevents efficient use of funds, as some amount need to be held in reserve as part of contingency to cover potential dispute occurrence during the construction phase (Touran 2003a), and thus results in project participants’ constant worry over what will happen in the future.

Drawing an analogy from the insurance industry where businesses and individuals transfer potential financial consequences of their loss to an insurer by purchasing an insurance product (Myhr and Markham 2003), one approach to reduce the negative influence of uncertain ADR implementation costs would be to structure and price those costs as an insurance product; this transfers the risk of unexpected high ADR implementation costs from the project participants to the insurance company. In return, the insurance company receives a premium which covers the company’s underwriting expenses and targeted profit. Although the risk transfer process does not directly eliminate the possibility that a dispute will occur, it does reimburse any ADR implementation costs associated with that dispute. Moreover, compared to the uneven occurrence of ADR implementation costs in the traditional self-funded model, periodic

payout of premium helps maintain a stable cash flow and thus makes it easier to budget and plan for insurance expenditures, as shown in Figure 5 (Adopted from Song et al. 2009).

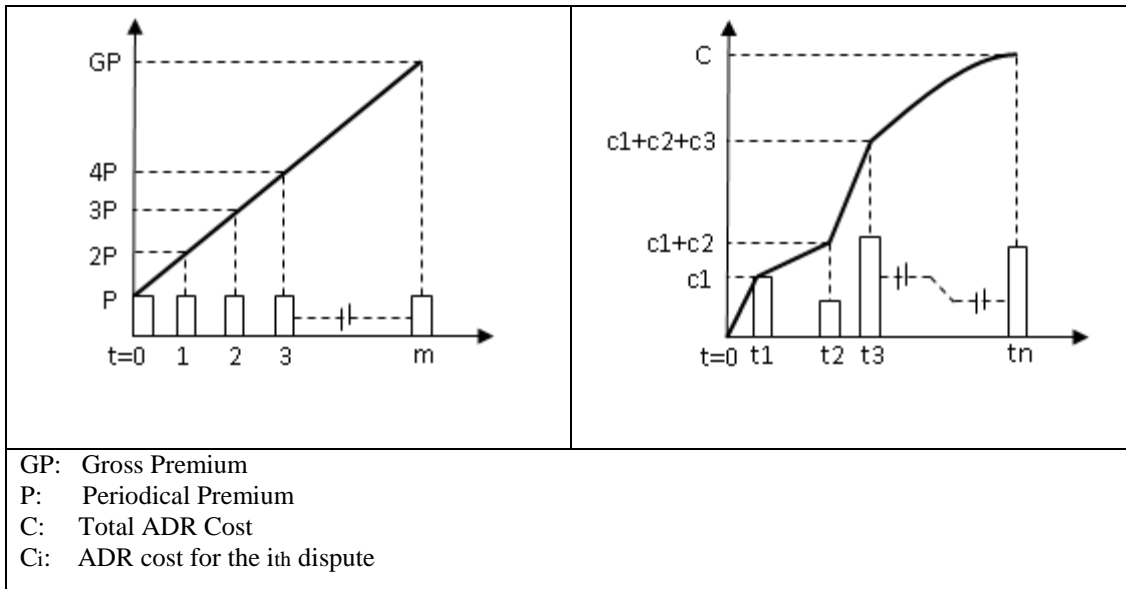


Figure 5: Comparison Of Cash Flows Of ADR Cost In Two Models

This paper proposes a methodology for the design of ADR implementation insurance. The purpose of this model is to provide a mutually advantageous insurance policy for both the insured and the insurer, thus providing project participants with an opportunity to invest a certain amount of premium in exchange for compensation from the insurance company in the event of unknown ADR implementation costs that may be incurred during the construction phase.

The paper is organized as follows. First, it investigates the possibility of using insurance for ADR implementation. Adopting utility theory from behavioral economics, subjective loss is used to represent the risk-averse attitude of project participants and to quantify the impact of ADR implementation costs in monetary terms. Next, a financial model is proposed on how to determine an acceptable premium for project participants

using Event Tree Analysis (ETA) (Hoshiya et al. 2004). Finally, a numerical example is presented to illustrate the application of the methodology.

## PROBLEM STATEMENT

Designing ADR implementation as an insurance product remains an uncharted area in both academia and industry. To understand the reason for this, it is important to have a basic idea of the pricing methodology used in the insurance industry to determine premium rates. There are three categories of ratemaking methods: pure premium method, loss ratio method and judgment method; among them, the most commonly used is the pure premium method, which develops rates from estimates of future claims and expenses based on an examination of historical claims and past expense experience (Myhr and Markman 2003). In simple terms, pure premium is the total expected loss for a specified period of time, and gross premium is the final premium paid to insurance company which equals pure premium plus an expense and profit loading (Myhr and Markman 2003). For example, assume for a specific project that the expected number of disputes is  $E(n)$ , the frequency of dispute occurrence, and the expected average ADR cost per dispute is  $E(c)$ , the expected severity of ADR implementation costs. According to previous work by Song et al. (2009), the gross premium for ADR insurance is

$$GP = E(C) + \alpha = E(n) \times E(c) + \alpha \quad \text{Eq. (3.1)}$$

Where  $E(c)$  is the pure premium or total expected ADR implementation costs, and  $\alpha$  is an expense loading factor to cover the expenses and target profits of the insurance company. As long as  $\alpha$  is greater than zero, then ADR insurance is meaningless to project participants on an expected value (EV) basis. In the EV theory, when a decision maker is facing uncertainty about a possible random loss  $X$ , he/she is willing to pay no more than

the expected loss amount  $E[X]$  in order to be relieved from future loss (Bowers et al., 1997). However, the premium that an insurance company charges as a return for bearing risk  $[E(c) + \alpha]$  is almost always greater than the expected dispute resolution cost  $E(c)$  because of  $\alpha$ . Thus, project participants might avoid investing in ADR implementation insurance and just hold the expectation that a project will be properly managed therefore it will not incur significant, unexpected ADR implementation costs. This decision-making process using EV theory exists in most insurance situations; for example, auto insurance, in which uninsured drivers often claim that they do not expect to have any accidents (Myhr and Markman 2003).

However, analogous to health insurance, in which individuals purchase policies to cover uncertain medical costs that they might incur in the future, decision makers do not necessarily follow the result that EV theory would predict. This is because most people are risk-averse to some degree; they are willing to pay a fixed insurance premium that is in excess of the mean expected value of ADR implementation costs in exchange for shedding some uncertainty about the future (Bowers et al. 1997). Some authors refer to this as an exchange of a certain loss (the premium) for an uncertain loss (Pritchett et al. 1996). Thus, quantifying the risk-averse attitude of project participants is the key to providing a mutually advantageous ADR implementation insurance policy.

## **UTILITY THEORY AND SUBJECTIVE LOSS FUNCTION**

Because EV does not capture a decision maker's risk attitudes, utility theory was developed to infer the subjective value or utility of different choices, and thus provide insights into decision making in the face of uncertainty (Bell et al. 1988, Keeney et al. 1993, Bowers et al. 1997, Norstad 2005). Utility function  $u(w)$  is used to indicate the

value or utility being attached to a certain wealth of amount  $w$  (Bowers et al. 1997). Subjective loss is defined as the negative value attached by project participants to the uncertain ADR implementation costs that they might incur based on their degree of aversion to the risk that they face. Unlike the traditional definition of a utility function, a subjective loss function (SLF) is used in this research to indicate the negative utility,  $u(c)$  that is attached to a given loss amount of ADR cost  $c$ , resulting from implementation of the dispute resolution process.

For example, consider the following scenarios: project participants can choose paying a premium of \$1,500 for sure or bearing the risk of incurring \$4,000 ADR implementation costs (with a probability of 0.3) or incurring nothing (with a probability of 0.7); in the other scenario, the option is between a certain premium of \$1.5 million and a possible ADR implementation costs of \$4 million (with a probability of 0.3). For project participants in the first scenario, purchasing insurance might not be favorable compared to simply bearing the risk of losing \$4,000, as the expected ADR cost is only \$1,200; however, for risk-averse project participants, if the negative prospect of incurring significant ADR implementation costs as high as \$4 million is taken into consideration, then there is motivation to consider investing in ADR implementation insurance. In this case, project participants make decisions based not on the expected loss (\$1.2 M) but on the subjective loss, which could be quantified by their subjective loss function,  $u(c)$ . In this case, the subjective loss is  $0.3 \times u(\$4 \text{ million})$  and  $u(\$4 \text{ million}) \geq \$4 \text{ million}$  for risk-averse project participants, because their subjective loss function is a convex upward function.

It is natural to assume that for risk-averse decision makers,  $u(c)$  is an increasing function, because “the more loss, the worse (more negative utility) it gets” (Bowers et al. 1997). For example, while an ADR implementation cost of \$4,000 might be of little concern to project participants, possible dispute resolution implementation costs of \$4 million are certainly worth considering. In addition, each additional equal increment of loss results in a larger increment of associated negative utility (Bowers et al. 1997). For example, a loss of \$2 million should have more than twice as much negative utility as a loss of \$1 million. This is the mirror image of the principle of decreasing marginal utility in economics (Bowers et al. 1997). In this paper, it is referred to as increasing marginal negative utility as shown in Figure 6 (Adopted from Song et al. 2010).

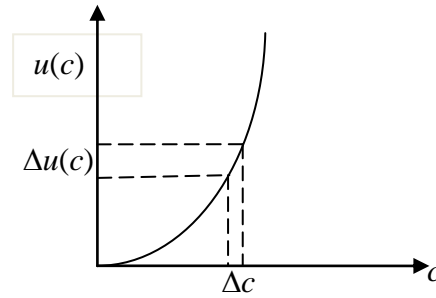


Figure 6: Characteristics of Subjective Loss Function

The two properties suggested by Figure 4 are  $u'(c) > 0$  and  $u''(c) > 0$ , where  $u'(c) = du/dc$  measures the slope of the line at each point of the curve;  $u'(c)$  being positive suggests that  $u(c)$  is an increasing function. The second inequality indicates that  $u(c)$  is a strictly convex upward function. From the viewpoint of the project participants, the maximum acceptable gross premium  $GP$  for assuming ADR implementation costs  $C$  is determined as follows (Hoshiya et al. 2004):

$$E(C) + \alpha = E(u(C)) \quad \text{Eq. (3.2)}$$



The left hand side of the equation represents the situation where the project has ADR implementation insurance; thus, project participants only need to pay the premium. The right hand side is the case without insurance, where project participants should bear all future losses. In the latter case, project participants view the undesirable financial outlay of possible uncertain ADR implementation costs subjectively with the function  $u$ , which quantifies their risk-averse attitude towards a future risk in monetary terms. In the former case, project participants could choose to carry insurance for certain.

According to Jensen's inequalities (Bowers et al. 1997), for a random variable  $X$  and function  $u(c)$  with a convex characteristic,

$$\text{If } u''(c) > 0, \text{ then } E[u(X)] \geq u[E(X)];$$

$$\text{If } u''(c) < 0, \text{ then } E[u(X)] \leq u[E(X)];$$

According to Eq. (3.2), the maximum premium that risk-averse project participants should be willing to pay is

$$GP = E[u(C)]$$

Combining this Jensen's inequalities

$$E[u(C)] \geq u[E(C)]$$

Then, for a risk-averse project participant, an acceptable maximum premium is:

$$GP \geq u[E(C)] \geq E(C)$$

In other words, the participant is willing to pay an amount greater than the expected value of ADR implementation costs for insurance to get rid of the uncertainty. Project participants with SLF  $u(c)$  are risk averse if, and only if,  $u''(c) > 0$  (Bowers et al. 1997). The relationship between  $GP$  and  $E[u(C)]$  is schematically illustrated in Figure 7.

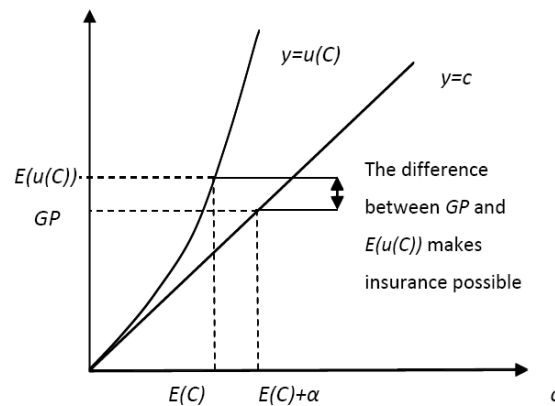


Figure 7: The relationship between  $GP$  and  $E[u(C)]$

### A SUBJECTIVE LOSS FUNCTION FOR ADR IMPLEMENTATION COSTS

Building the SLF of project participants is a way to change their qualitative preference from alternatives that have uncertain payoffs with a consistent numerical comparison (Bowers et al. 1997). The process could be complicated, because it is a matter of subjective judgment and depends on many factors such as conflicting attitudes toward risk among project participants, project type, and environment of financial market (Bowers et al. 1997). Even for the same project participants, different projects will have different subjective loss functions that require re-evaluation (Bowers et al. 1997). Usually, SLF is expressed by several elementary functions such as quadratic, exponential, and fractional power functions (Bowers et al. 1997). It can be obtained by conducting a financial survey with project participants to determine the negative utilities (in monetary units) that they attach to a series of future losses.

## ADR IMPLEMENTATION INSURANCE MODEL

The ADR implementation insurance model is constructed to help project participants determine whether investing in ADR implementation insurance is beneficial for a certain project. It includes five key parts as shown in Figure 8.

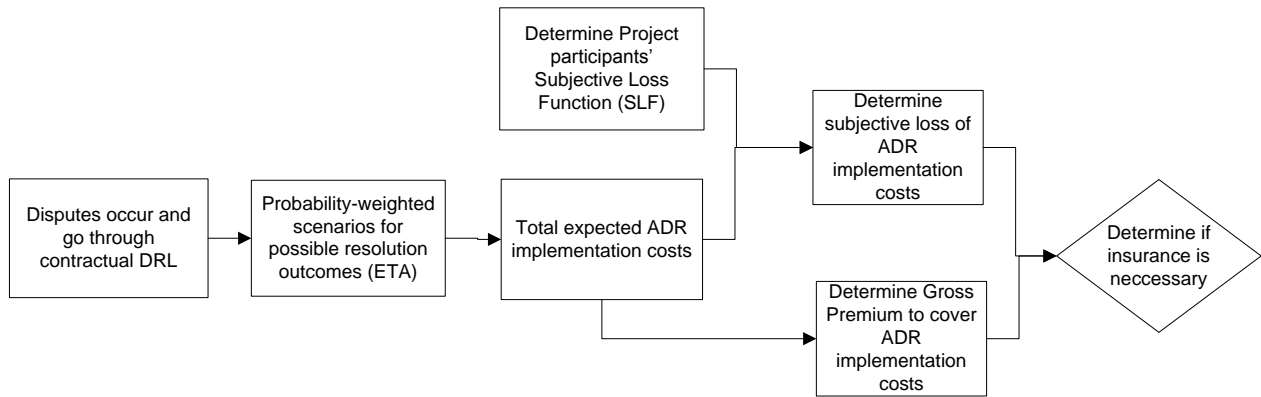


Figure 8: Analytic Flow Of The ADR Insurance Model

Each stage in Figure 6 will be evaluated on the basis of past experience, statistical data and the unique characteristics of a project. Specifically, ETA is applied to simulate scenarios of dispute resolution outcomes and to determine the probability mass function of expected ADR implementation costs (Hoshiya et al. 2004). Then, gross premium (as quoted from an insurance company) is calculated and compared with the maximum fixed cost derived from subjective loss to determine whether insurance is acceptable to project participants.

### *Event Tree Analysis*

Event Tree Analysis (ETA) is a graphical representation of a logic model that identifies and quantifies all possible outcomes resulting from an accidental initiating event (Rausand and Høyland 2005). By studying all relevant accidental events, ETA can be

used to identify all potential accident scenarios and sequences in a complex system. To determine the frequencies of outcomes, let  $P(y)$  denote the frequency of the initiating event; let  $P(xi)$  denote the probability of event  $xi$ . Once the Initiating event  $Y$  has occurred, according to conditional probability (Ang and Tang 2006), the probability of outcome  $X$  is:

$$P(\text{Outcome } X | \text{Initiating event } Y) = P(x_1 \cap x_2 \cap x_3 \dots \cap x_n) \\ = P(x_1) \times P(x_2 / x_1) \times P(x_3 / x_1 \cap x_2) \dots \times P(x_n / x_1 \cap x_2 \cap \dots \cap x_{n-1})$$

Then the frequency of Outcome  $X$  is:

$$P(x) = P(y) \times P(x_1) \times P(x_2 / x_1) \times P(x_3 / x_1 \cap x_2) \dots \times P(x_n / x_1 \cap x_2 \cap \dots \cap x_{n-1})$$

The frequencies of the other outcomes can be determined in a similar way.

In seismic risk analysis, ETA is utilized to identify the sequential damage and their probabilities to a concerned structure (Hoshiya et al. 2004; U.S. Nuclear Regulatory Commission 1975). In this paper, ETA is used to help identify scenarios of dispute resolution process and quantitatively determine the probability of corresponding ADR implementation cost, making it possible to calculate the total expected ADR implementation costs. It first sets up the event of dispute occurrence as a specified condition. Assume the contractual Dispute Resolution Ladder (DRL) has  $m$  stages on the ladder: ADR1, ADR2, ..., ADR $m$ . For the  $j$ th stage, assume the effectiveness of ADR $j$  is  $k_j$ , and the average cost for ADR $i$  is  $c_j$ . For example,  $k_1 = 0.5$  means 50% of the disputes can be resolved in the first stage. When a dispute occurs, it first goes to ADR1, the first stage of the contractual DRL. If dispute resolution does not come to a satisfied settlement by both parties, it will go to the next stage ADR2, and so on. The whole process is shown in Figure 9.

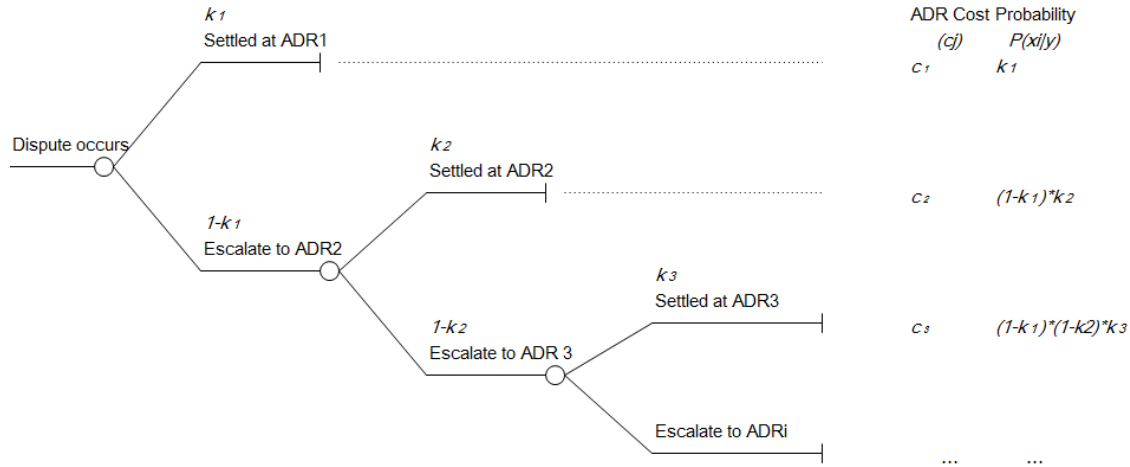


Figure 9: ETA of ADR Implementation Costs

### ***Total Expected ADR Implementation Costs***

Without loss of generality, the risk of incurring ADR implementation costs in any construction project can be mathematically represented as follows:

1. By  $n$ , the total number of disputes occurring in the period [from the notice to proceed ( $t = 0$ ) to the project completion ( $t = T$ )];  $n = N_1, N_2, \dots, N_k$  with probability  $q_1, q_2, \dots, q_k$  respectively, where  $N_1$  is the minimum possible number of disputes and  $N_1 \geq 0$ , while  $N_k$  is the maximum number of possible disputes. Since construction disputes occur randomly over time, the arrival of disputes can be approximated with a Poisson Process (Touran 2003b). Let  $t_1$  be the time of the first dispute occurrence and  $t_i$  be the time elapsed between the  $(i-1)$ th and  $i$ th events,  $i > 1$ ;  $\{t_i\}$  is the sequence of interarrival times. In a Poisson process,  $t_1, t_2, \dots$  are independent and identically distributed with an exponential ( $\lambda$ ) distribution, where  $\lambda$  is the rate of dispute occurrence. Although the Poisson Process shows very good memory-less properties, it does not necessarily fit reality because it cannot model situations where the occurrence rate  $\lambda$  changes

over time. Thus, to simulate construction dispute occurrence, a non-homogenous Poisson Process is used where  $\lambda$  is a function of time  $t$  expressed as  $\lambda(t)$ .

2. By  $c_j$ , the average amount of ADR implementation costs for each dispute resolution process, where  $j = 1, 2, \dots, m$  represents the  $j$ th stage on the contractual DRL. Then, for each dispute, its resolution process bears  $m$  possible outcomes: resolved at ADR1 and cost  $c_1$ , resolved at ADR2 and cost  $c_2$ , ... , resolved at ADR $m$  and cost  $c_m$ , with probability  $p_1$ ,  $p_2$ , and  $p_m$ , respectively, in which  $\sum_{j=1}^m p_j = 1$ . According to Figure 7, the following can be obtained:

$$p_j = (1 - k_1)(1 - k_2) \dots (1 - k_{j-1})k_j \quad \text{Eq. (3.3)}$$

Assume that the cost on each stage is independent.

3. For the  $i$ th dispute ( $i=1,2,\dots,n$ ), define  $x_{ij} = 1$  represents that the  $i$ th dispute is resolved on the  $j$ th stage; otherwise,  $x_{ij} = 0$ . Thus  $x_j = \sum_{i=1}^n x_{ij}$  represents the total number of disputes that are resolved in the  $j$ th stage and follows a multinomial distribution  $M(n, p_1 p_2, \dots, p_m)$ , with the expected value  $E(x_j) = n \times p_j$ , where  $j = 1, 2, \dots, m$ . Specifically, when  $m = 2$ , then  $x_j$  follows binomial distribution  $B(n, p_1 p_2)$ .  $E(x_j)$  is the expected number of disputes that are resolved on the  $j$ th stage.
4. Among all  $n$  disputes, a total of  $R$  different possible outcomes exists. For each outcome, there could be  $x_j$  disputes resolved with ADR $j$ . Consequently, the total ADR implementation cost throughout the time horizon for the  $r$ th outcome is  $C_r = \sum_{j=1}^m c_j x_j$  with a probability of  $P_r = \prod_{j=1}^m p_j^{x_j}$ , given a total of  $n$  disputes. The number of outcome which bears the same total cost and probability is

$$\binom{n}{x_1 \dots x_j \dots x_m}.$$

Then the total expected ADR cost is:

$$\begin{aligned}
E(C) &= \sum_{n=N_1}^{N_k} q_n \sum_{r=1}^R \binom{n}{x_1 \dots x_j \dots x_m} C_r P_r \\
&= \sum_{n=N_1}^{N_k} q_n \sum_{r=1}^R \binom{n}{x_1 \dots x_j \dots x_m} \sum_{j=1}^m c_j x_j \prod_{j=1}^m p_j^{x_j} \\
&= \sum_{n=N_1}^{N_k} q_n \sum_{j=1}^m c_j \left( \sum_{r=1}^R \binom{n}{x_1 \dots x_j \dots x_m} \prod_{j=1}^m p_j^{x_j} \right) x_j \\
&= \sum_{n=N_1}^{N_k} q_n \sum_{j=1}^m c_j (n p_j) \\
&= \sum_{n=N_1}^{N_k} n q_n \sum_{j=1}^m c_j p_j
\end{aligned} \tag{3.4}$$

### ***Total Expected Subjective Loss of ADR Cost***

As mentioned earlier, a subjective loss function (SLF) is used to indicate the negative utility  $u(c)$  that project participants attach to a given loss amount of ADR implementation costs  $C$  resulting from dispute resolution. The total expected subjective loss could be expressed as follows:

$$E(u(C)) = \sum_{n=N_1}^{N_k} p_n SL_n \tag{3.5}$$

where  $SL_n$  is the total subjective loss when the total number of disputes is  $n$ .

Eq. (3.6) defines the total expected subjective loss as

$$SL_n = \sum_{r=1}^R \left( \left( x_1 \cdots x_j \cdots x_m \right) \prod_{j=1}^m p_j^{x_j} \left( \sum_{j=1}^m x_j u(c_j) \right) \right) \quad \text{Eq. (3.6)}$$

### ***Comparison between Gross Premium and Total Expected Subjective Loss***

The last step of the model is to compare the gross premium and expected subjective loss and determine whether investing in ADR implementation insurance is favorable. According to Eq. (3.2), if  $GP \leq E(u(C))$ , then there exists the possibility for an insurance policy.

### **ILLUSTRATIVE EXAMPLE**

Assume there is a highway bridge project in which project participants decide to include a three-step DRL in the contract for dispute resolution ( $m = 3$ ). In this DRL, a dispute goes through the Architect/Engineer or Supervising Officer (ADR1) to mediation (ADR2) and then arbitration (ADR3). If the DRL fails to provide a satisfactory settlement, then dispute resolution will eventually escalate to litigation, which will be much more costly. Details are shown in Figure 10 (Adapted from Menassa et al. 2010).



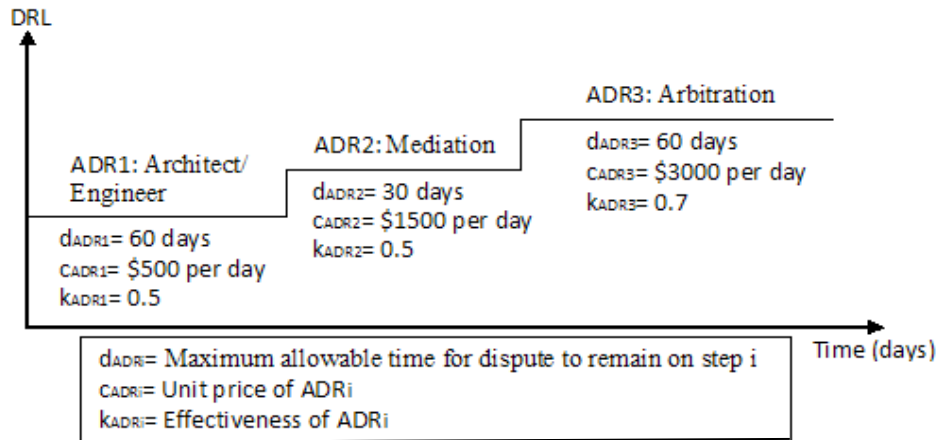


Figure 10: Project DRL

The estimated duration of this project is  $T = 720$  days from Notice To Proceed (assuming 30 days in each month,  $T = 24$  months). Assuming that disputes occur according to a nonhomogenous Poisson process, and the rate of dispute occurrence is

$$\lambda(t) \begin{cases} 2 & t \in [0,8] \\ 4 & t \in (8,16] \\ 3 & t \in (16,24] \end{cases}$$

In this case, disputes occur more frequently in the middle phase and towards the end of the project, which is comparatively realistic because more and more problems would emerge as the project processes.

To determine the total expected ADR implementation costs, ETA, is determined as in Figure 11.

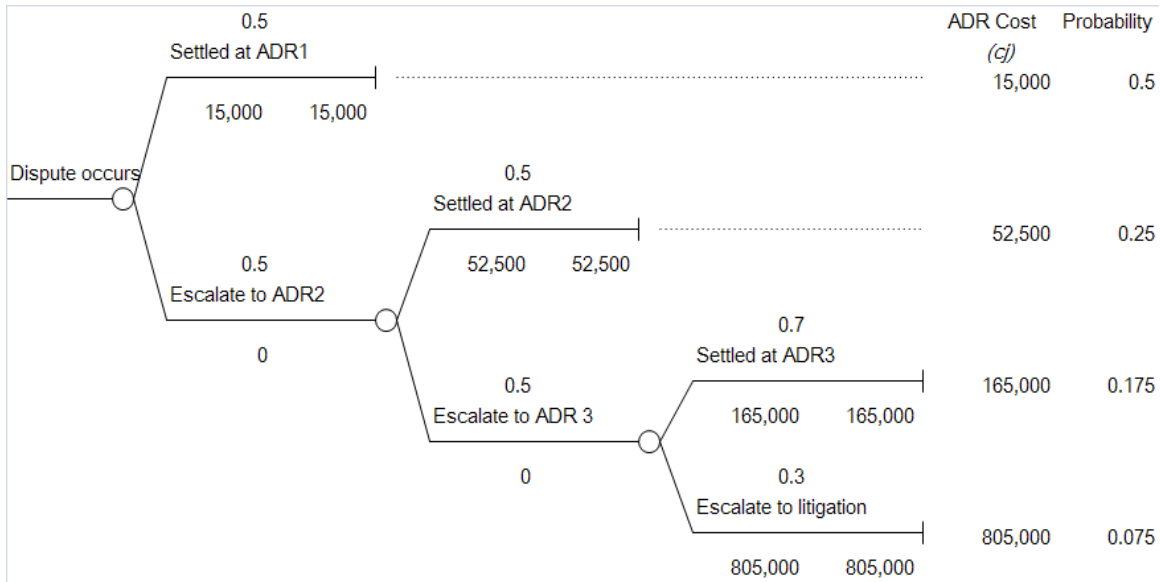


Figure 11: Project ETA Of ADR Cost

The following SLF is then adopted:

$$u(x) = x + 1880[\exp(0.007x) - 1]$$

which is calculated based on 96 samples taken from insurance purchasing owners in a financial survey (Hoshiya 2004). The reason for adopting this particular SLF is because: First, it bears the properties necessary to represent a risk-averse attitude, as we can easily obtain that  $u'(c) = 1 + 13.16 \times \exp(0.007x) > 0$  and  $u''(c) = 0.09212 \times \exp(0.007x) > 0$ . Second, it is the closest function form which can be used to estimate our pilot data. Last but not the least, exponential function is one of the fundamental functions and is easy to comprehend and calculate.

Table 7 and Figure 12 show one run of the simulation. It includes when a dispute incurs (t/day); on which stage of the DRL is it resolved (ADR1-Architect/Engineer; ADR2-mediation; ADR3-arbitration; and ADR4-eventually goes to litigation); and finally the implementation costs and project participants' subjective loss for each dispute resolution.

Table 7: Simulation Results For One Run

No.	t/day	ADR	ADR Implementation Costs (c)/MM\$	Subjective Loss (u(c))/MM\$
1	32	1	0.015	0.212
2	34	4	0.805	11.429
3	36	4	0.805	11.429
4	40	1	0.015	0.212
5	50	1	0.015	0.212
6	81	4	0.805	11.429
7	90	1	0.015	0.212
8	108	4	0.805	11.429
9	125	1	0.015	0.212
10	132	2	0.0525	0.744
...				
71	634	1	0.015	0.212
72	646	1	0.015	0.212
73	648	3	0.165	2.338
74	654	1	0.015	0.212
75	671	1	0.015	0.212
76	692	2	0.0525	0.744
77	706	3	0.165	2.338
78	712	2	0.0525	0.744
Total (MM\$)			12.52	177.67

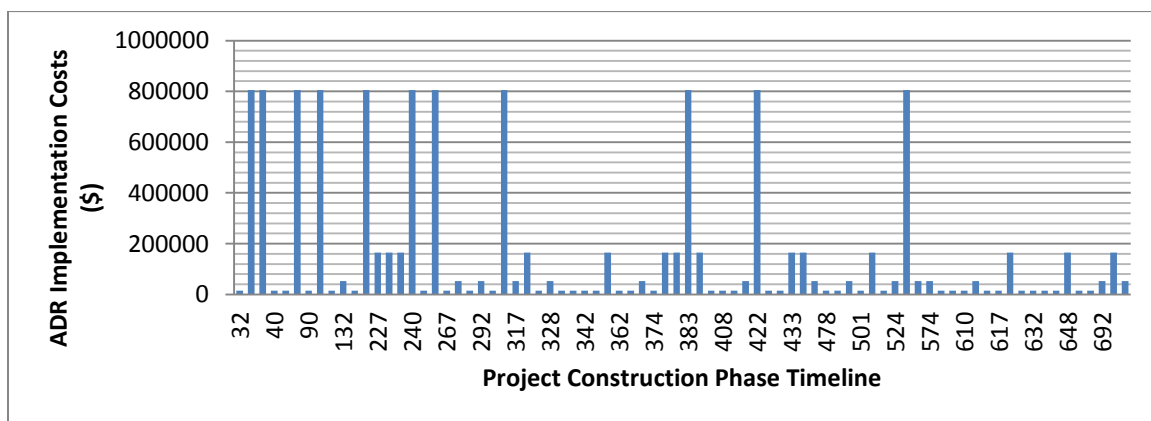


Figure 12: Illustrative Example Of ADR Implementation Costs And Distribution

The results of 1000 simulation runs and a 25% expense loading for the gross premium are presented in Table 8.

Table 8: Simulation Results

Average No. of Disputes	Expected ADR Implementation Costs $E(C)$ (MM\$)	Expected Subjective Loss $E(u(C))$ (MM\$)	Gross Premium GP(MM\$)
75	7.96	112.90	9.95

Then, according to Eq. (3.2), a maximum fixed-loss  $GP$  that satisfies the following equation should exist to make insurance attractive to a participant:

$$GP = 9.95 \leq E[u(C)] = 112.90$$

This means that project participants are willing to pay more than the expected loss to transfer the risk from themselves to the insurance company. For a  $GP$  of \$9.95 million, insurance would be an attractive option for project participants. In other words, for this specific project, the insurance company can potentially charge an expense loading factor (ELF) of more than 25%. Therefore, the gross premium for the ADR implementation insurance is feasible and mutually advantageous to both the project participants and the insurance company.

## CONCLUSION

Pricing ADR implementation insurance is a complex process that involves many factors. This paper investigates the application of utility theory in the decision-making process for project participants to invest in ADR implementation insurance. Subjective loss can better represent risk-averse project participants in evaluating uncertainty, thus providing a

possible explanation for the validity of third-party insurance in construction management. Using subjective loss makes an insurance policy possible for risk-averse project participants despite the fact that the gross premium is higher than the expected loss. Moreover, Event Tree Analysis can serve as an effective tool to find the probability for each step on the DRL and to obtain the expected loss. This ADR implementation insurance, although not a tool to eliminate the possibility of a dispute resolution cost, is a powerful alternative in risk management to transfer the financial risk to a third party.

Future research should focus on the following aspects. First, sensitivity analysis should be conducted on critical parameters such as the effectiveness of  $ADR_i$  ( $k_i$ ), the average ADR implementation costs for each DRL stage ( $c_i$ ), and the assumption of possible disputes (distribution parameters). Second, the time value of money should be applied to the model to make it more realistic. Third, the deductible should be included in the insurance policy to prevent moral hazard. In this case, the maximum gross premium that project participants would accept is determined in a different way, as they will carry part of the future loss too. Finally, there will be close work with the industry on how to make this type of insurance more feasible with real projects.

## Chapter 4

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### **DETERMINING THE OPTIMAL PREMIUM FOR ADR IMPLEMENTATION INSURANCE IN CONSTRUCTION DISPUTE RESOLUTION<sup>6</sup>**

#### **ABSTRACT**

In most of today's construction projects, disputes are almost inevitable, and the implementation costs associated with dispute resolution are becoming increasingly expensive. One approach to deal with the risk of dispute-related cost overruns is by pooling the risk using Alternative Dispute Resolution (ADR) implementation insurance. This innovative insurance product is designed to allow the insurance company to compensate any ADR implementation cost that project participants incur during the construction phase. In return, the insurance company will receive a premium for bearing the risk of excessive ADR implementation costs. Similar to commercial medical and auto insurance, the ADR insurance policy specifies a Deductible Limit (DL) and a Maximum Payment Limit (MPL) on project participants to prevent both moral and morale hazards. In this case, project participants must bear part of the future ADR implementation costs before their insurance is activated. Based on the basic framework of ADR implementation insurance previously developed by the writers, this paper proposes an advanced model with the two additional insurance limits to help determine the optimal point on the project participants' subjective loss curve. The objective is to provide a mutually advantageous insurance policy and minimize project participants' total expected

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<sup>6</sup> This paper was co-authored with Feniosky Peña-Mora, Carol C. Menassa, and Carlos A. Arboleda. It was currently in review of the ASCE Journal of Management in Engineering

subjective loss. An example is provided to illustrate the benefits of the proposed methodology. The results show that project participants' Subjective Loss Function (SLF), DL, MPL, and the Expense Loading Factor  $\alpha$  together play important roles in determining the optimal premium for the ADR implementation insurance.

## INTRODUCTION

Completing a construction project without incurring any disputes is an elusive goal for most project participants, since conflict has become an inherent characteristic of this industry (Peña-Mora et al. 2003). In response to financially expensive and emotionally draining litigation, many systems and procedures have been developed to address disputes within the construction industry (Gebken II and Gibson 2006). While a considerable amount of research has been conducted on various Alternative Dispute Resolution (ADR) techniques (Zack 1997, Rubin et al. 1999, Harmon 2003, Peña-Mora et al. 2003, Chan et al. 2006, Cheung et al. 2006, El-adaway and Kandil 2010), few studies have focused on how to reduce the negative impact of high ADR implementation costs associated with dispute resolution (Diekmann and Nelson 1985, Adrian 1988, Gebken II and Gibson 2006). In this study, implementation costs were not considered as the settlement amount of a dispute; rather, they refer specifically to the cost of implementing ADR techniques during the dispute resolution process, including fees and expenses paid to the owner's/contractor's employees, lawyers, claims consultants, third-party neutrals, and other experts associated with the resolution process (Gebken II and Gibson 2006, Menassa et al. 2009). According to Gebken II and Gibson 2006, direct costs incurred during the dispute resolution process alone can equate to almost 2% of the entire contract amount before any consideration of indirect or hidden costs, such as

injured business relationships or loss of productivity. From the perspective of risk management, one approach to mitigate this negative impact on the project budget, which is likely already financially stressed, is to price ADR implementation costs as an insurance product (Song et al. 2011). Insurance, as a risk financing tool, transfers the risk of unexpected high ADR implementation costs from project participants to the insurance company. In return, the insurance company receives a premium that covers the company's underwriting expenses and targeted profit.

The previous research by the writers proposed a basic framework for the ADR implementation insurance model, but two additional policies should be applied to prevent moral and morale hazards (Pritchett et al. 1996). In insurance analysis, the term “moral hazards” refers to a condition that “increases the likelihood that a person will intentionally cause or exaggerate a loss” (Myhr and Markham 2003). It often involves bad faith on the part of the insured. For example, faking the theft of a laptop in an effort to obtain a new one is a moral hazard. Morale hazards are “attitudes of carelessness and lack of concern that increase the chance of a loss occurring or increase the size of losses that do occur” (Pritchett et al. 1996). Reckless driving is a typical example of a morale hazard in auto insurance. Both moral and morale hazards describe different behaviors of the insured when protected from risk and when fully exposed to risk. The difference is that the former is considered malicious, while the latter is mainly due to indifference. Similarly, project participants who deliberately prolong a dispute resolution process are suspected of creating a moral hazard. On the other hand, a poor communication system that prevents efficient dispute resolution is an example of a morale hazard. To address the potential risk of these two types of hazards, the ADR implementation insurance policy



will include a Deductible Limit (DL) and a Maximum Payment Limit (MPL) on project participants. Figure 13 shows the insurance structure. Project participants will bear the first part of any ADR implementation costs that are incurred up to the DL as well as any costs that exceed the MPL. Together, these two limits play an important role in determining the insurance premium.

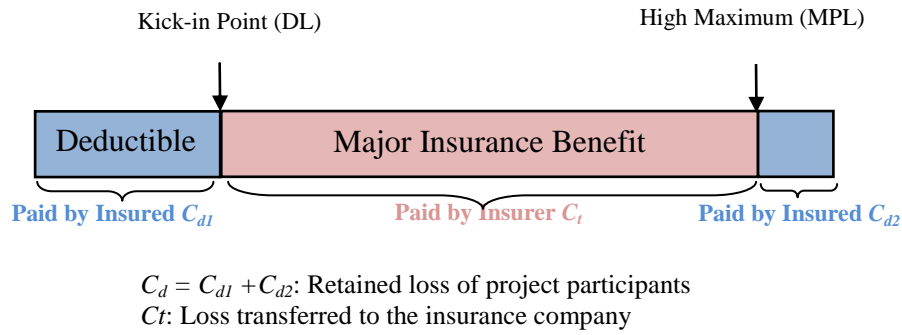


Figure 13: Structure of ADR Implementation Insurance

This paper introduces an insurance model that incorporates uncertainties in potential ADR implementation costs and calculates the optimal premium for the insured based on the expected total loss and expected total subjective loss. Note that because of DL and MPL, project participants must be responsible for part of the future ADR implementation costs instead of completely relying on the insurance company to take the risk. As a result, their expected total loss and expected total subjective loss will increase and further affect the terms of the insurance policy. The intent of this study is to provide a mutually advantageous insurance policy for both the insured and the insurer, thus providing project participants with a certain degree of confidence against possible dispute-related cost overruns.

## PROBLEM STATEMENT

Before proceeding to the insurance model, the condition of a maximum acceptable premium is stated to help project participants understand and accept the merit of ADR implementation insurance in the light of financial loss implications. Assume that  $C$  is the total ADR implementation costs for a certain construction project. Insurance will cover the loss in the range between  $DL$  and  $MPL$ , as shown in Fig. 11 (Hoshiya et al. 2004). Thus, the total loss incurred can be expressed as:

$$C = C_d + C_t \quad \text{Eq. (4.1)}$$

where  $C_d$  is the retained loss of project participants, and  $C_t$  is the part that is transferred to the insurance company. From the perspective of project participants, the maximum acceptable Gross Premium ( $GP$ ) is determined as follows (Hoshiya et al. 2004, Song et al. 2011):

$$E(u(C)) = E(u(C_d)) + E(C_t) + \alpha \quad \text{Eq. (4.2)}$$

$$GP = E(C_t) + \alpha \quad \text{Eq. (4.3)}$$

Where:

$E[u(C)]$  = Total Expected Subjective Loss

$E[u(C_d)]$  = Expected Subjective Loss for project participants under insurance coverage

$E(C_t)$  = Expected Loss for the insurance company

$\alpha$  = Expense Loading Factor

$GP$  = Gross Premium as charged by the insurance company

The left-hand side of Eq. (4.2) represents the situation in which the project does not carry ADR implementation insurance. As a result, project participants must bear all potential future loss  $C$ . The right-hand side of Eq. (4.2) is the case with insurance, in

which project participants can choose to pay a certain amount of premium  $GP$  plus an uncertain amount of retained loss below the DL and above the MPL, as shown in Fig. 11, where  $\alpha$  is the Expense Loading Factor included in  $GP$  to cover the insurance company's underwriting expenses and targeted profit. In both cases, project participants view the undesirable financial outlay of possible uncertain loss subjectively with a subjective loss function (SLF)  $u$ , which quantifies project participants' risk-averse attitude towards a future risk in monetary terms (Song et al. 2011).

According to Bowers et al. (1997) and Song et al. (2011), project participants with SLF  $u(c)$  are risk averse if, and only if  $u''(c) > 0$ . This means that the SLF for risk-averse project participants is a strictly convex upward function. The relationship between  $GP$  and  $E[u(C)]$  is illustrated schematically in Figure 14. The left graph shows the situation in which insurance is attractive for project participants, while the right graph shows the opposite for much less risk-averse project participants.

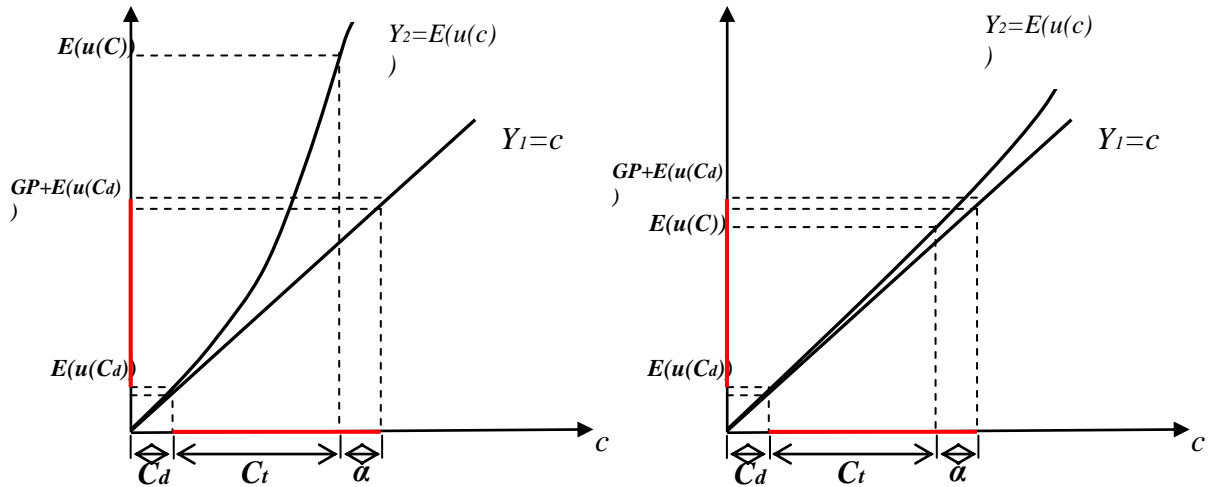


Figure 14: Schematic Illustration Of The Relationship Between  $GP$  And  $E[u(C)]$

#### ADR IMPLEMENTATION INSURANCE MODEL

The flowchart developed by Song et al. (2011) serves as the first step in the model to determine whether an insurance policy formulated by the insurance company is beneficial for a specific project. The model proposed in this paper as shown in Figure 15 (Adapted from Hoshiya et al. 2004, Song et al. 2011) is an advanced version with Deductible Limit (DL) and Maximum Payment Limit (MPL) added to the policy. First, it assumes that disputes occur and go through the contractual Dispute Resolution Ladder (DRL), which is a predetermined procedure for dispute resolution that involves multiple ADR techniques (USACE 1989, Caltrans 2000, Peña-Mora et al. 2003). Disputes escalate from the lower stage to the higher stage if no satisfactory settlement is achieved within the maximum allowable time on each stage. Then, Event Tree Analysis (ETA) is applied to determine the Total Expected Loss  $E(C)$  for a certain project and to determine the Total Expected Subjective Loss  $E[u(C)]$  for project participants, taking their Subjective Loss Function into consideration. If the simulation results indicate that a mutually acceptable insurance policy exists between project participants and the insurance company, then the Expected Subjective Loss  $E[u(C_d)]$  for project participants under insurance coverage and the Expected Loss  $E(C_t)$  for the insurance company are calculated. Based on this, the model gives the optimal premium among different combinations of MPL, DL and  $\alpha$ .

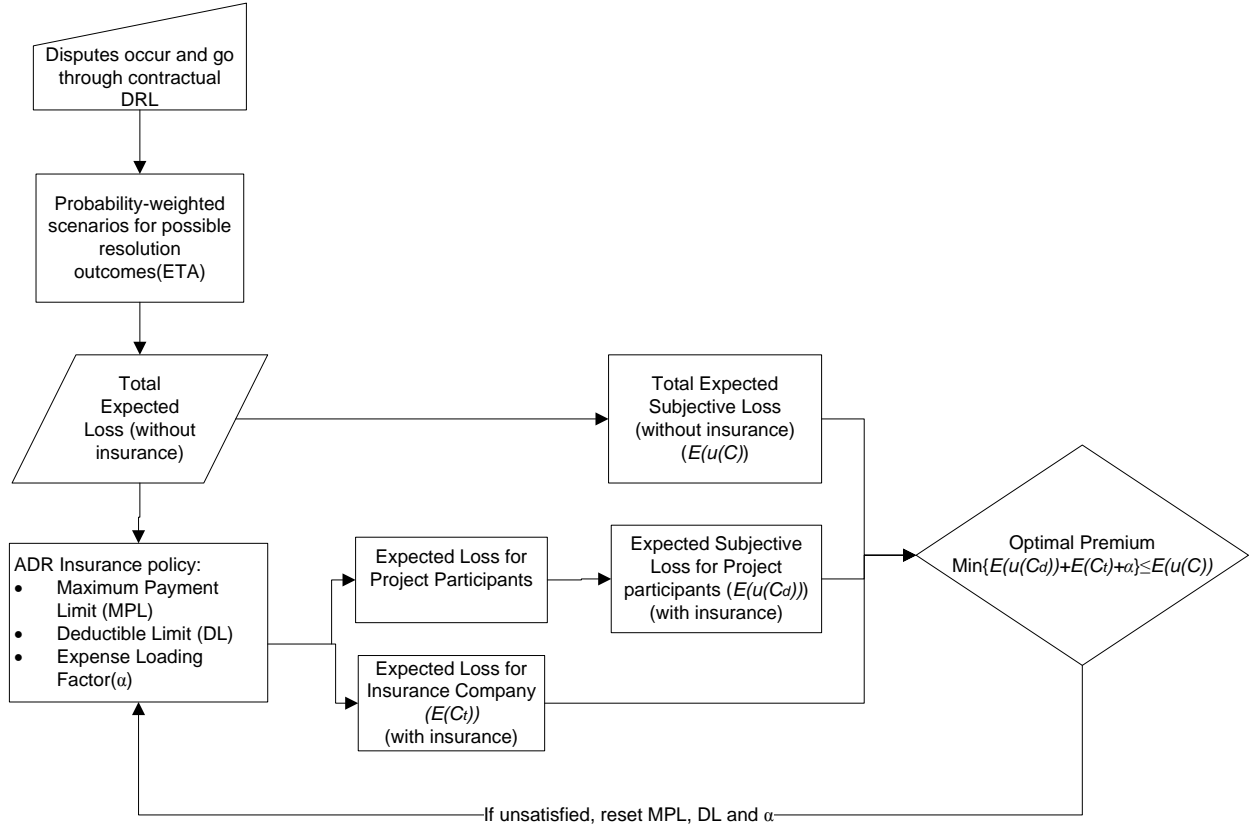


Figure 15: ADR Insurance Model For Determining The Optimal Premium

Again, Figure 7 from Chapter 2 shows the structure of the Event Tree Analysis (ETA). It first sets up the event of dispute occurrence as a specified condition. Then, the dispute goes through the contractual Dispute Resolution Ladder (DRL), which has  $m$  stages of  $ADR_1$ ,  $ADR_2, \dots$ , and  $ADR_m$  until final settlement. For the  $j$ th stage, assume that the effectiveness of  $ADR_j$  is  $k_j$ , which is based on historical data and is used to determine the conditional probability of a certain dispute being resolved with  $ADR_i$ . Furthermore, assume that the cost  $c_i$  for successfully resolving a dispute with  $ADR_i$  has a normal distribution with mean  $\mu_i$  and standard deviation  $\sigma_i$ , and is left truncated at 0 (Touran 2003). The value of the parameters is based on the research results of Zucherman (2007b), which will be described later. Of course, project participants could use a distribution regressed from their own historical data of dispute resolution costs to achieve

greater accuracy. Finally, ETA generates probability-weighted scenarios for possible resolution outcomes of all disputes that occurred during the project. Note that each dispute resolution process is assumed to be independent.

The next step in the model is to determine the Total Expected Loss  $E(C)$  and the Total Expected Subjective Loss  $E[u(C)]$  for project participants with a set of insurance policies. It is determined by Eq. (3.4) in Chapter 3.

### **ILLUSTRATIVE EXAMPLE**

The standard dispute resolution process for government construction contracts in Hong Kong usually includes a three-step DRL (Peña-Mora et al. 2003). In this DRL, the design professional is responsible for the first determination concerning any disputes that arise. Then project participants have 28 days to refer the matter to mediation if no satisfactory settlement can be achieved. On the non-mandatory mediation level, 42 days are allowed to resolve disputes before they escalate to arbitration. Finally, the arbitrator has 28 days to issue a final binding determination for settlement, subject to the completion of the work. This paper presents a similar DRL as an example to demonstrate the proposed ADR insurance model. The effectiveness of each ADR can be determined by statistical data from the project participants' past experience. Assume that the cost of solving a dispute with a specific ADR has normal distribution truncated at zero. The mean value is determined from the average hourly or daily rate of mediators or arbitrators from the American Arbitration Association from different parts of the U.S. According to Zucherman (2007b), an arbitrator's compensation is estimated to be \$2,200 at the per diem rate and the mediator's compensation to be \$310 at the hourly rate. Based on these rates, Zucherman estimated that the average cost of arbitration for a hypothetical, two-

party construction dispute is \$94,500, while the outlay for mediation is \$10,140. Because ADR implementation costs are subject to wide variation based on the degree of complexity of the dispute, assume the coefficient of variation to be 0.5 for all three distributions. Again, this value should be based on the past experience of project participants. The stepwise approach is shown graphically in Figure 16.

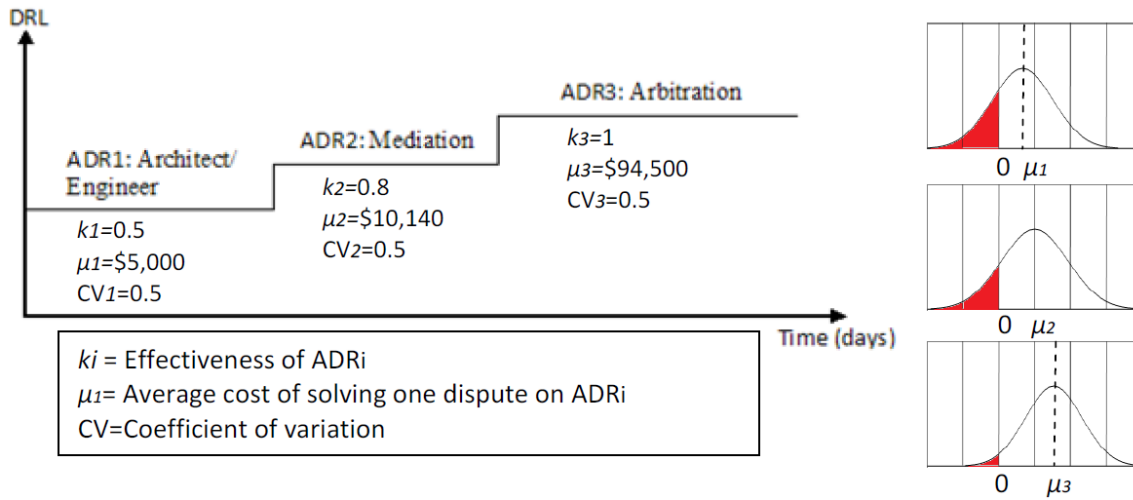


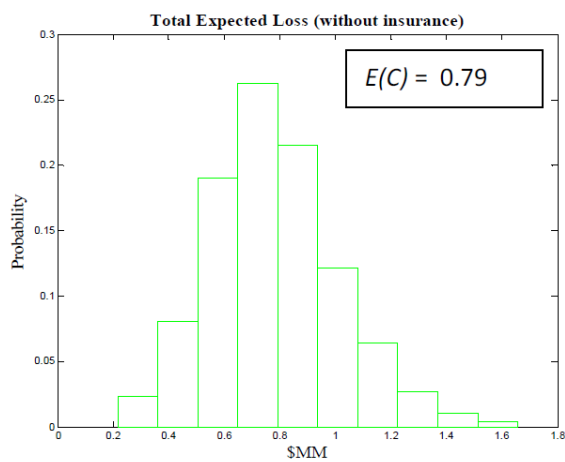
Figure 16: Project DRL And Distribution Of Resolution Costs Of Each ADR

Assume for a highway bridge project that the estimated duration is  $T = 24$  months and that disputes occur according to a Poisson process with mean rate  $\lambda = 2$  (Touran 2003). The following SLF was used:

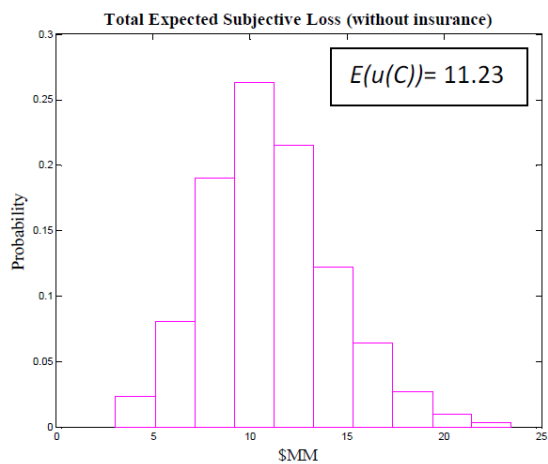
$$u(x) = x + 1880[\exp(0.007x) - 1] \quad \text{Eq. (4.4)}$$

The function was calculated based on 96 samples taken from insurance purchasing owners in a financial survey (Hoshiya et al. 2004).

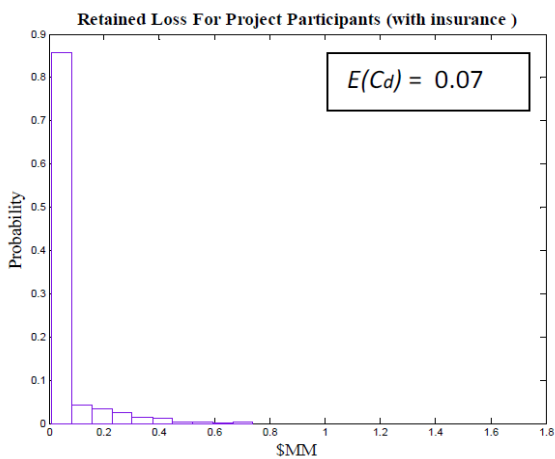
In the simulation, the probability mass functions for project participants and the insurance company were evaluated with a DL of 5% and an MPL of \$1 million. The Gross Premium was calculated with a 25% Expense Loading Factor. Figure 17 is based on the results of 1,000 simulation runs:



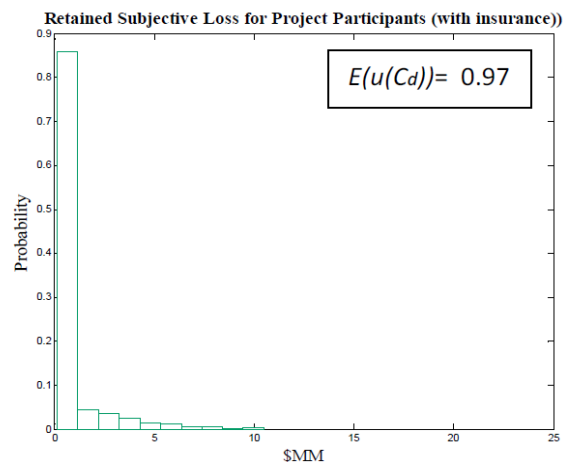
(a)



(b)



(c)



(d)



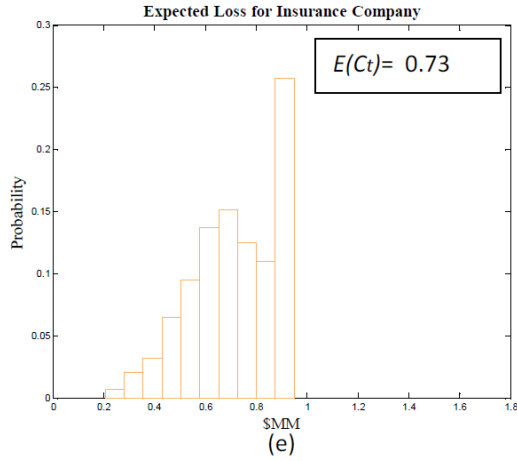


Figure 17: Different Scenarios Of Probability Mass Functions For Project Participants And Insurance Company

Recalling Eq. (4.2), a gross premium  $GP$  is acceptable for project participants if, and only if:

$$E(u(C)) \geq E(u(C_d)) + GP$$

$$GP = E(C_t) + \alpha$$

In this case,

$$E(u(C)) = \$11.23 \text{ MM}$$

$$GP = E(C_t) + \alpha = 0.73 * 1.25 = \$0.91 \text{ MM}$$

$$E(u(C_d)) + GP = 0.97 + 0.91 = \$1.88 \text{ MM}$$

which satisfies the condition described in Eq. (4.2). This means that project participants are willing to pay a gross premium of \$0.91 MM to avoid the possibility of uncertain ADR implementation costs, which are distributed in a wide range of up to \$1.8 million dollars under the specified insurance policy.

## ANALYSIS OF RESULTS

While fixing  $\alpha$  at 25%, the optimal premium was investigated by varying two parameters, DL and MPL, which impact both the insured and the insurer. According to Eq. (4.1), the optimal premium is achieved when the right-hand side of the equation reaches its lowest point. Figure 18 shows the impact of different MPL and DL values on Expected Subjective Loss, Expected Retained Subjective Loss, and the gross premium.

In Figure 18 (a), the MPL varies from 40% to 160% of the Expected Total Loss, while the DL and  $\alpha$  are set at 5% and 25%, respectively. The minimum point of curve  $E[u(C_d)] + GP$  is reached when the MPL is 130% of the Expected Total Loss. With the MPL at 130% and  $\alpha$  at 25%, the DL varies from 0 to 14%. These results show that the optimal premium is obtained when the DL is 0. However, as mentioned before, an insurance policy should include the DL to avoid moral and morale hazards. Thus, despite the results, a 5% DL, which is commonly used in the insurance industry, was adopted in the model.

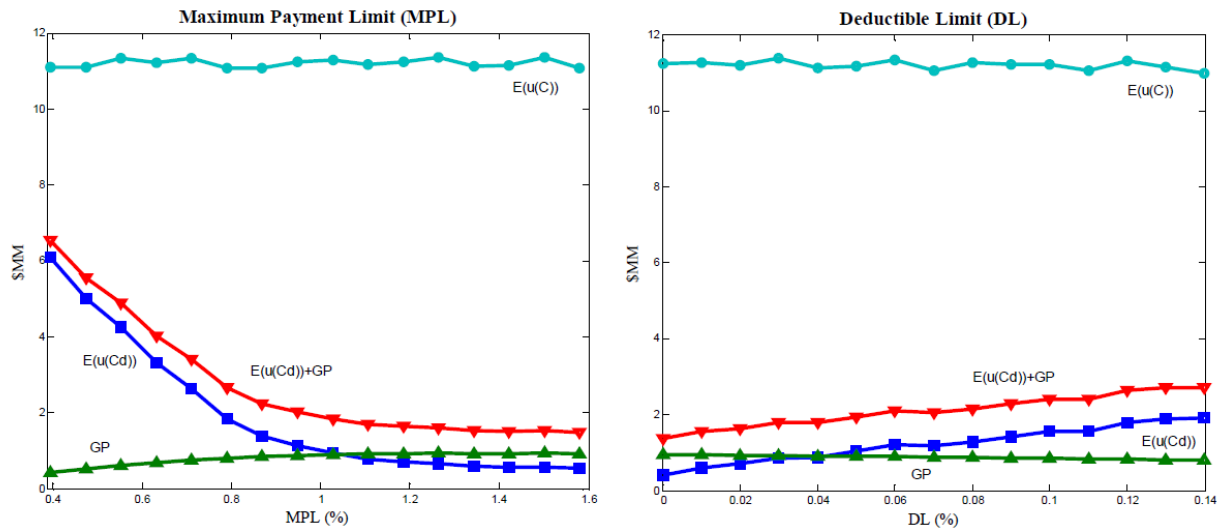


Figure 18: Impacts Of MPL And DL

Of course, the optimal combination of MPL and DL will differ with different subjective loss functions. An acceptable insurance policy depends largely on the project participants' degree of risk aversion. In addition to the exponential function used in the model, several elementary functions are commonly used to illustrate the properties of subjective loss functions, such as fraction power functions, quadratic functions, and logarithmic functions (Bowers et al. 1997).

Figure 19(a) shows an example of risk-neutral project participants whose subjective loss function is  $u(c) = c$ . In this case, because of the expense loading factor  $\alpha$ , purchasing insurance will not be a favorable choice for project participants, which is obvious since  $E[u(C_d)] + GP$  is always larger than  $E[u(C)]$ . Figure 19 (b) presents the case of a quadratic subjective loss function  $u(c) = c^2 + 1.5c$ . It represents risk averse project participants, because it satisfies  $u'(c) > 0$  and  $u''(c) > 0$ . Figure 19 (b) suggests that, with 5% DL and 25%  $\alpha$ , purchasing insurance is not feasible if the MPL is less than 50%. The optimal point is reached at 110% MPL. For an insurance policy to be acceptable to project participants with 50% MPL and 5% DL, the Expense Loading Factor  $\alpha$  should not exceed 40%, as shown in Figure 19 (c).

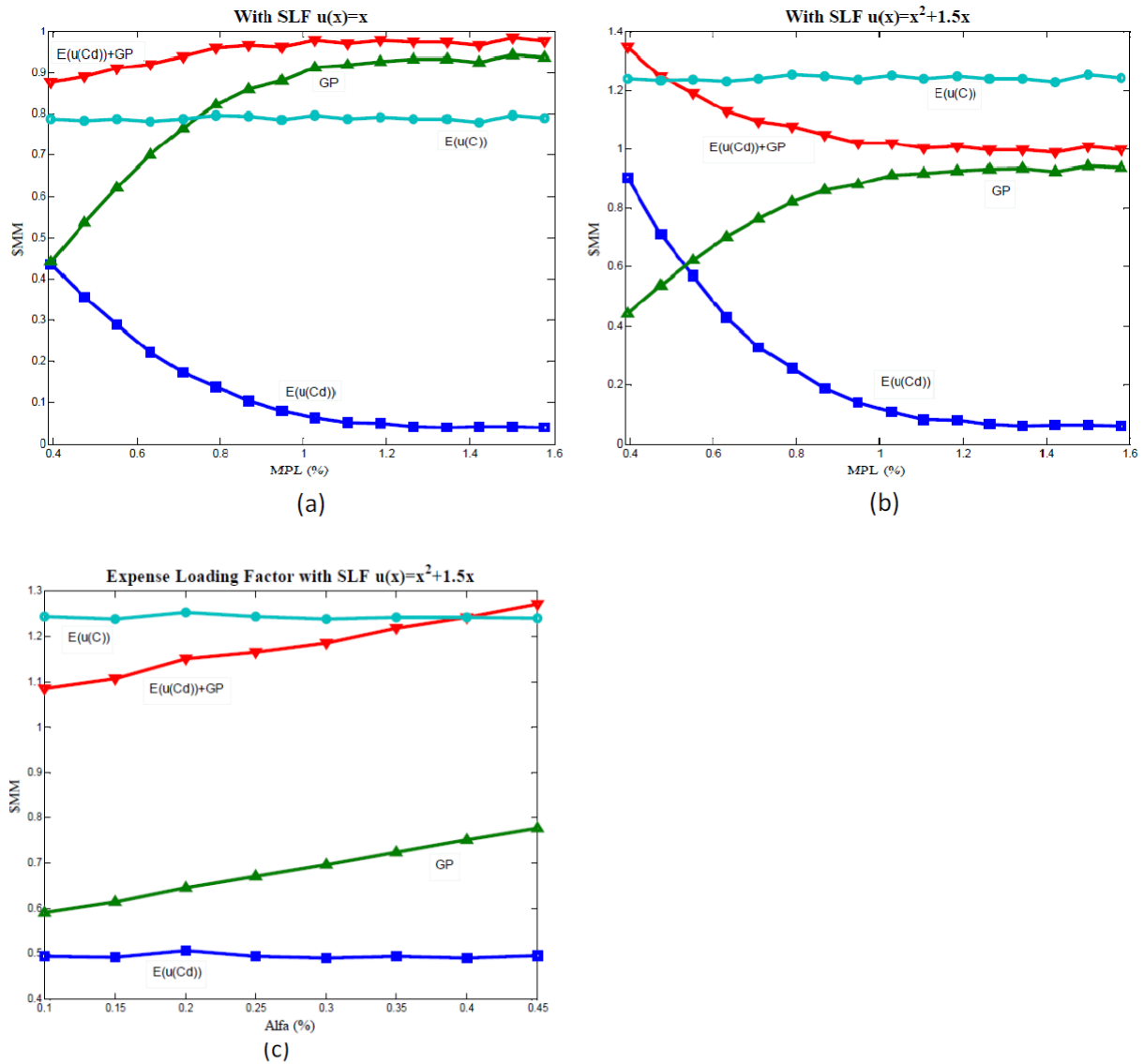


Figure 19: Simulation With Different Subjective Loss Functions

## MODEL VALIDATION

As discussed before, the ADR insurance model proceeds along the following analytical path. First, the key parameters describing the specific dispute and the contractual insurance policy are determined. The model then estimates the incidence of dispute resolution outcome from the dispute resolution process. Finally, the resulting cost for both project participants and the insurance company are estimated based on the

characteristics of the dispute and the policy terms. More specifically, a probabilistic ADR insurance model contains the following five basic steps:

1. Assess the likelihood of dispute occurrence for a project.
2. Estimate the dispute resolution outcomes, given the characteristics of the DRL and the disputes.
3. Estimate the resolution costs, given the outcomes.
4. Estimate the losses for both parties, given the resolution cost and the policy terms.
5. Determine the feasibility of the insurance policy for the project.

The ADR insurance model contains a comprehensive set of hypothetical events, each with an assigned probability. The event set is intended to provide a representative sampling of possible dispute resolution outcomes, the frequency and the severity. Thus, it produces an estimate of the range of possible losses for project participants and the insurance company, which further helps project participants determine whether a certain insurance policy is attractive or not.

At each of the steps, local validation could be performed by “Testing Against Experience” method. Testing against experience is a common validation tool in the insurance industry (Sandstrom 2005). It compares the model’s predictions for a particular parameter to the available historical actual dataset (Collins and Lowe 2001, Sandstrom 2005). For example, the model’s probability of dispute occurrence frequency can be validated by comparison to projects completed by the same project participants with similar duration, contract value, and delivery methods, etc. Similarly, the dispute resolution outcome and associated average cost, which largely depends on the effectiveness of each ADR on the contractual DRL can be compared to the actual

resolution process in a historical event. The dispute data used in the simulation of the illustrative example is adopted from a construction project that has several unsolved disputes. To further validate the model, future work will continue to focus on data collection and analysis.

Because of estimation errors and uncaptured inter-relationships among variables, it is expected that the model results do not fully agree with actual observations. The following list presents some of the key contributors to ADR insurance model error:

- Limited availability of key parameters for a sufficient number of construction disputes resolved by different ADR techniques.
- Limited ability to simulate the actual dispute occurrence.
- Limited ability to simulate all the possible dispute resolution outcomes because of the interdependence between disputes.
- Limited knowledge of the precise cost for a dispute resolution process.

## CONCLUSIONS

This paper investigates the role of ADR implementation insurance and proposed a methodology for determining the optimal premium. By establishing a mutually advantageous insurance policy and a rational premium that is acceptable to both project participants and the insurance company, ADR implementation insurance becomes a powerful risk management tool for construction projects. Through the study, the following conclusions were reached:

1. Based on the framework of Song et al. (2011), a Deductible Limit (DL) and a Maximum Payment Limit (MPL) are added to the ADR insurance policy to

- prevent potential moral and morale hazards and thus encourage project participants to minimize the likelihood of dispute occurrence or to resolve disputes on the lower stage of the Dispute Resolution Ladder.
2. From the project participants' prospective, future uncertain ADR implementation cost is measured using a Subjective Loss Function. An optimal premium is achieved when the right-hand side of Eq. (4.1) reaches its minimum. Simulation results suggest that the DL is normally a fixed value as adopted by the insurance industry. The MPL and the Expense Loading Factor  $\alpha$ , which are proportional to the Expected Total Loss are two important variables in the optimization process. Depending on different risk attitudes of project participants, different values of MPL and  $\alpha$  are required to make insurance acceptable.
  3. However, the study had several limitations. First, the Subjective Loss Function used in the simulation was taken directly from the research of Hoshiya et al. (2004) without further exploring the mechanism of establishing a user-oriented SLF. However, as mentioned in the paper, SLF should be obtained for each individual project in order to capture project participants' risk attitudes accurately. Second, independence between disputes was assumed to simplify the model. However, a real situation in which overlapping dispute resolution processes impact one another due to limited available resources could be more complicated. Thus, the correlation between disputes should be further investigated. Third, while feedback from the construction industry generally expressed interest and support for the design of ADR implementation insurance, future research will be necessary to determine how to apply it to real projects. In future work, an

experiment will be conducted with one project of our cooperating construction company to help validate the model. In addition to ADR implementation insurance, the industry is looking for a new product that covers not only ADR but also any legal expenses that are not covered by standard insurance. To meet such need, this research must be expanded to explore the possibility of developing a non-reimbursed expense insurance.



## Chapter 5

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### CONTRIBUTIONS

This dissertation investigates the application of insurance as a risk management tool for ADR implementation in construction disputes. The objective is to provide a mutually advantageous insurance policy for project participants and a third party. Three questions are addressed:

- Why should ADR techniques be priced as an insurance product?
- How should one structure ADR insurance policies?
- How should one determine whether an insurance package is suitable for a certain project?

To answer these questions, I compare the known cost of purchasing insurance for ADR implementation with the unknown cost of retaining the risk of uncertain disputes costs. In doing so, risk-averse project participants can transfer the risk of uncertainty of future disputes costs to a third party insurance provider. Chapters 2 to 4 built upon one another to provide evidence to answer these questions. Chapter 2 drew analogies from health insurance to explore the role of insurance in the construction dispute resolution domain. Chapter 3 took this concept a step further by considering the risk attitudes of project participants via utility theory. Chapter 4 completed the framework by adding two additional insurance limits to the model developed in the Chapter 3.

The main contribution of this dissertation is the development of a framework that structures ADR techniques as an insurance product. This ADR implementation insurance allows project participants to transfer the risk of uncertain dispute resolution costs to a

third party. Because most projects in today's construction industry are financially stressed, the model presented in this dissertation provides project participants with an economic advantage by investing a premium in the beginning of the project in exchange for compensation from an insurance company in the uncertain event of unknown ADR costs that may be incurred during the construction phase. In all, the findings from this research expand current knowledge on construction dispute resolution from a risk management perspective.

The development of an innovative insurance product in these three chapters has significant implications for the construction and insurance industries. For the former, such an insurance product provides a valid approach to transfer the risk of unexpected ADR costs. For the latter, offering such an insurance product could create a unique business opportunity to differentiate an insurance company from its competitors. This is especially important for the success of insurance companies in today's competitive market. By revealing the key structure of ADR insurance, I intend that this dissertation contributes to bridge the gap between existing insurance packages and non-reimbursed expenses incurred during the dispute resolution process.

In later section, I will discuss the theoretical and academic contributions of Chapters 2, 3, and 4, respectively.

## **ADR INSURANCE FOR DIFFERENT PROJECT PARTICIPANTS**

Unlike many other businesses that only form two-party transactions, a construction dispute resolution process could involve numerous separate, yet interdependent parties, such as the owner, general contractor, subcontractors, suppliers, architect, engineer, and perhaps a number of sureties and insurance carriers (Cushman 2001). According to

Gebken II and Gibson (2006), in a survey of 48 sample projects, there were 43 general contractors, 40 owners, 23 subcontractors, 16 architects, 7 bonding companies, and 2 vendors involved in some disputes. As for dispute resolution costs, Gebken II and Gibson (2006) estimated that 30% were collected from the owners while 47% and 19% were collected from general contractors and subcontractors, respectively. Architects, engineers, and equipment vendors accounted for the remaining 4%.

Recall from Chapter 1 that sometimes the dispute resolution costs could be as high as 2% of the entire contract value. Such costs could have catastrophic impacts on the parties involved. This is especially true for the owner, general contractor, and subcontractors, who contribute approximately 96% of the cost. Thus, for these parties, the idea of investing in ADR insurance and transferring the cost to the insurance company could be especially attractive.

## **INDIVIDUAL CONTRIBUTIONS**

The following sections discuss the contributions of each chapter in further detail.

### ***Chapter 2: Applying Insurance Pricing Theory for Pricing ADR as an Insurance Product***

In Chapter 2, I first introduce the well-developed theory of insurance pricing to the uncharted area of construction risk management. Specifically, I draw on an analogy from health insurance, which provides the patients with the benefit of reduced medical expenses in case of unexpected sickness. ADR implementation insurance resembles health insurance in high severity and high frequency. Recognizing the similarity, I further investigate the feasibility of ADR insurance. To that purpose, I adopt insurance pricing

theory to price ADR techniques as an insurance product to address the risk of incurring exorbitant dispute resolution costs. I first develop a simple model to structure ADR implementation insurance using the pure premium method. This method provides project participants with an option to prearrange ADR implementation costs through a fixed-cost investment in an insurance-like product, rather than to set aside a certain percentage of contingency fees from the beginning of a project to deal with potential disputes. In doing so, project participants are relieved from the constant anxiety over uncertainty as unknown ADR implementation costs would be compensated by a third party. This, in turn, allows project participants to use funds more efficiently.

### ***Chapter 3: Insurance As A Risk Management Tool For ADR Implementation In Construction Disputes***

In Chapter 3, I adopt the concept of subjective loss to measure project participants' attitudes toward risk. The most significant contribution of this chapter is that it provides a possible explanation for the validity of third-party insurance in construction management. A major challenge in developing ADR implementation insurance is that it is not attractive to project participants based on an expected value (EV) perspective. This is the case because insurance companies consider an expense-loading factor,  $\alpha$ , to calculate the premium that covers the insurance company's underwriting expense and profit. To address this challenge, I follow the lead of Hoshiya et al. (2004) and adopt utility theory to infer the subjective value or utility of different choices in the face of uncertainty. A subjective loss is defined as the negative value attached by project participants to uncertain ADR implementation costs, which depends on participants' attitudes toward risk. Hence, a subjective loss function could be used to represent the risk-averse attitude

of project participants and quantify the negative impact of ADR implementation costs in monetary terms. Subsequently, I mathematically prove that risk-averse project participants are willing to pay a fixed insurance premium that is higher than the mean expected value of ADR implementation costs in exchange for shedding future uncertainty. The results further show that, as long as the gross premium of ADR insurance is lower than project participants' subjective loss, there is a common ground for a mutually beneficial insurance policy between project participants and the insurance company, which could have significant implications for industry.

#### ***Chapter 4: Determining the Optimal Premium For ADR Implementation Insurance In Construction Dispute Resolution***

In addition to the theoretical contribution of the previous two chapters, Chapter 4 presents a comprehensive framework that incorporates uncertainties in potential ADR implementation costs to answer two questions: (1) Is an insurance policy is beneficial for a certain project? and (2) if so, what is the optimal premium for project participants? The model first assumes that disputes occur and go through the contractual Dispute Resolution Ladder (DRL), which is a predetermined procedure for dispute resolution and involves multiple ADR techniques. Disputes escalate from the lower stage to higher stage if no satisfying settlement is achieved within the maximum allowable time at each stage. Event Tree Analysis (ETA) is then applied to simulate probability-weighted scenarios for possible dispute resolution outcomes and determine the probability mass function of ADR implementation costs by drawing an analogy from seismic risk insurance. Moreover, the insurance policy would have a Deductible Limit (DL) and Maximum Payment Limit (MPL) on project participants to prevent moral and morale hazards. In

this case, project participants would bear part of future ADR implementation costs before insurance is activated. The next step is to determine the total expected subjective loss for project participants, which considering their subjective loss function. If the simulation results indicate that a mutually acceptable insurance policy exists between project participants and the insurance company, then the expected subjective loss for project participants with insurance coverage and the expected loss for the insurance company are calculated. The model then determines the optimal point on a project participants' subjective loss curve, which minimizes their total expected subjective loss. More importantly, throughout the development of the model, I was able to present my work to the industry, in particular, the Risk Management Group at Turner Construction Co. The valuable comments and feedback that I received allowed me to modify the underlying concepts and assumptions to make it more applicable to the industry. I believe continuing work with this group will benefit my future work on sustainability risk management.

## Chapter 6

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### **LIMITATIONS AND SUGGESTED DIRECTIONS FOR FUTURE RESEARCH**

The focus of this research is the potential application of ADR implementation insurance as an insurance product for project participants to manage the risk of incurring exorbitant costs when implementing ADR techniques. I approach this problem by comparing the subjective loss of uncertain resolution costs against the insurance premium charged by a third party. When subjective loss is high, such an insurance product is valid and project participants can successfully transfer risk to a third party. This unique topic has not yet been extensively studied in related literature. Thus, the model presented in this dissertation could serve as a foreshadowing of future events in construction risk management. Like any other models, however, this is not without its shortcomings. Here, I discuss three major limitations on modeling assumptions and industrial application.

#### ***Limitation 1: Subjective Loss Function***

This dissertation adopts the concept of subjective loss to capture the risk attitudes of project participants and evaluate the negative impact of an ADR implementation cost on a project. As illustrated in Chapters 2 and 3, a Subjective Loss Function (SLF) is used to quantify a decision maker's risk-averse attitude toward future risk in monetary terms. Because of my limited access to project participants in real-world projects, the SLF used in the numerical examples were taken directly from the research results of Hoshiya et al. (2004). The reader should refer to Chapter 2 for a detailed discussion of the properties of the SLF and the rationale for this chosen simulation. However, in real-world application,

a SLF should be obtained for each individual project capture project participants' risk attitudes accurately. Here, I briefly introduce how to use utility theory to construct a SLF for a specific construction project with a simple systematic approach presented by Bowers et al. (1997).

- First, assign two utility values to two losses  $c_1$  and  $c_2$ . Without loss of generality, define  $c_1 = 0$  to represent the situation with no loss.
- Second, ask the question: what is the maximum monetary value of  $G$  that project participants would be willing to pay for complete insurance protection against random loss of no loss ( $c_1 = 0$ ) with probability  $1 - p$  and assuming  $c_2$  with probability  $p$ ? Expressing this in mathematical terms, the question for project participants to fix a value  $G$  such that:

$$u(G) = E[u(C)] = (1 - p) \times u(c_1) + p \times u(c_2) \quad \text{Eq. (6.1)}$$

Once the value  $G = c_3$  is available, add  $[c_3, (1 - p) \times u(c_1) + p \times u(c_2)]$  as another point on the SLF.

- Repeating above steps, project participants could add as many points as necessary.
- Fit all points with a smooth function to obtain a SLF that characterizes participants risk aversion.

Consider the following oversimplified example as an illustration. Assuming that, for a project, there are two points on project participants' SLF, which are assigned utilities of 0 and 1, respectively,  $u(0) = 0$  and  $u(20,000) = 1$ . Suppose an ADR cost of \$20,000 might be incurred with probability 0.5, or no ADR cost is incurred with probability 0.5 (in reality, an Event Tree Analysis (ETA) might be used to analyze the



event of incurring ADR costs  $c_n$  with probability  $p_n$ ). Project participants are then asked to determine the value  $G$  so that:

$$u(G) = 0.5 \times u(20,000) + 0.5 \times u(0) = 0.5$$

Here, if participants pay  $G$ , then their loss will certainly remain at  $G$ , instead of the uncertain \$20,000. The equal sign indicates that project participants are indifferent in paying  $G$  with certainty and accepting the expected subjective loss.

Assume that project participants decide that  $G = \$12,000$ . Then,

$$u(12,000) = 0.5$$

From this, we can conclude that there is a possibility that participants would be willing to pay an insurance premium of  $G = \$12,000$ , which is greater than the expected loss of  $E(C) = 0.5 \times 0 + 0.5 \times 20,000 = \$10,000$ .

This result is illustrated in Figure 20 with the dash line representing the subjective loss function and the solid line representing the expected value perspective. The approximated SLF consists of line segments with positive slopes. If we continue this process and obtain more points on the curve, we can generate a smooth curve that bears the properties of  $u'(c) > 0$  and  $u''(c) < 0$ , as long as we are dealing with risk-averse project participants.

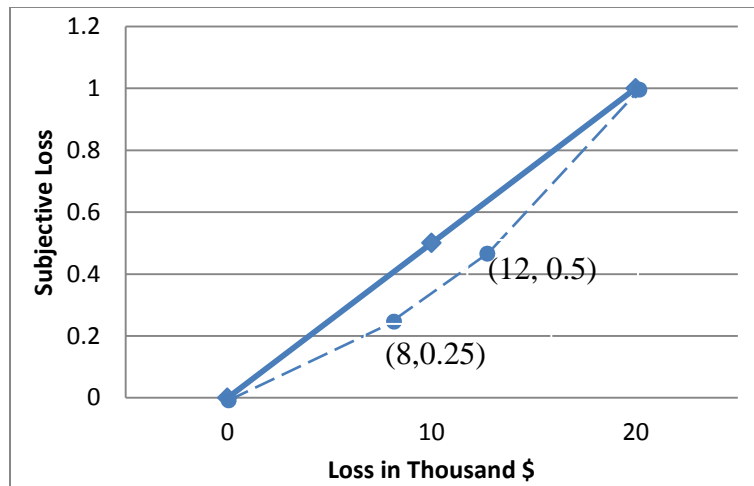


Figure 20: Building A User-Oriented SLF

SLF provides a way to represent project participants' qualitative preferences over alternatives of uncertain payoffs with a consistent quantitative comparison. Although the above procedure appears simple, building a SLF can be a rather complicated process because the process is a matter of subjective judgment that depends on many factors such as conflicting risk attitudes among project participants, project type, financial environment, etc. (Bowers et al. 1997). Even for the same project participants, different projects will have different subjective loss functions, thus subjective loss must be re-evaluated for each project. In utility theory, utility function can be represented by several elementary functions such as exponential, fractional power, and quadratic functions, to name a few (Bowers et al. 1997). In this dissertation, exponential function is adopted as project participants' SLF as explained in Chapter 3. For projects that require user-oriented SLF, variables in the SLF could be estimated using regression. To elaborate, first a financial survey should be conducted for project participants to show their different perceptions of a given series of loss values. Then, with several points plotted on the SLF line, the regression of the actual loss values and the impact of those losses (valued by

project participants in comparison to previous established utility values) become the subjective loss function.

***Limitation 2: the assumption of independence among dispute resolution processes***

In this dissertation, I assume that dispute resolution processes are independent from each other. As a result, Poisson process, with its mathematical property of memorylessness (Willkomm et al. 2009) is adopted to simulate the occurrence of disputes. This means that the number of disputes that occur in any bounded interval after time  $t$  is independent from the number of arrivals that occur before time  $t$  (Cannizzaro 1978). Touran's (2003) research on a probabilistic model for cost contingency provides strong theoretical support for using Poisson process to simulate the number of disputes occurred in a given time interval. However, the real situation could be more complicated and the assumption of independence among disputes may be unrealistic. On one hand, overlapping dispute resolution processes could have a negative impact on one another because the project has limited resources available to allocate to different disputes. On the other hand, the occurrence of one dispute could be the prelude of more disputes. Moreover, in real practice, project participants may utilize the "Total Cost" approach to handle disputes in a way that a number of heads of disputes are rolled up into one single dispute (MBB 2007). Although the "Total Cost" method is not favorable if another method is possible because of its inaccuracy (Irwin 2005), it does require modification to the assumption of independence among different dispute resolution processes if such method is adopted. In this case, when identifying scenarios of dispute resolution outcomes, the ETA, as shown in Figure 9 will generate multi-way splits instead of binary situations because more than one dispute is processed on each node. In this dissertation, the model is limited to binary

choices to avoid too many possibilities for the next split in the tree based on the assumption of independence. However, for all the reasons discussed above, among others, the correlation between disputes should be further investigated.

***Limitation 3: the time value of money***

This dissertation presents the background material and the method for calculating the net single premium, which is the one-time charge required by the insurance company in order to carry risks specified in the insurance policy (Dorfman and Adelman 1992). After making the lump sum payment in full at the beginning of the contract term, the insured would expect the insurer to remain obligated to pay all benefits and deliver its future promises without incurring any extra costs. An alternative is to purchase ADR insurance in installments. For example, in the illustrative example in Chapter 3, the gross premium is a total of \$9.95 million. Instead of paying one large amount at the inception of the contract, project participants may choose to purchase a series of periodically renewable term insurance contracts, also known as the level premium (Gerber 1997). This type of payment structure is common among commercial insurance lines such as auto insurance, life insurance and health insurance, as illustrated in Figure 5.

For large-scaled infrastructure project, the ADR insurance contract could last for many years, and the time value of money become an important issue. In the dissertation, the illustrative examples involve a 2-year project, thus the time value of money is not considered for the convenience of the discussion; however, different premium payment structure will have a dynamic impact on the project's financial statements (Dorfman and Adelman 1992), and the time value of money could come into play in many ways. For example, in lieu of a single lump sum payment at the beginning of the policy, money can

be invested at a positive rate of interest until funds are needed to the next premium. As a result, future research should include the discounted time value of money of all future benefits in the calculation of the final sum of premium when long contractual periods are involved.

***Limitation 4: application of ADR insurance in industry***

This dissertation aims to provide a mutually advantageous insurance policy for project participants and third party insurance providers. While feedbacks from the construction industry generally suggests interest and support for the design of such an ADR implementation insurance, future research is necessary to determine how to apply it to real projects. In future work, an experiment will be conducted to study the projects of our cooperating construction company with the aim to validate the model developed in this research. In addition to ADR implementation insurance, the construction industry is looking for a new insurance product that covers ADR implementation as well as any legal expenses that are not covered by standard insurance. To meet such a need, this research must be extended to explore the possibility of developing a non-reimbursed expense insurance.

***Future Research***

In this dissertation, I draw upon utility theory and insurance pricing theory that have been well-developed in behavior economics and risk management science to address problems in the dispute resolution domain of a construction project. The results demonstrate that when project participants are risk-averse toward uncertain dispute costs, an ADR implementation insurance can be an effective way to transfer such risk of from the project

participants to a third party. A natural extension of this research is to explore the applicability of the results by examining the modeling assumptions limited above.

This research is by no means the end, rather it provides a fundamental framework that can be extended to solve more similar problems in the construction industry. One possible application is the area of sustainable construction. In the next section, I will discuss the framework for developing Emission Liability insurance.

With growing concern about global warming and climate change, the construction industry, as a major contributor to greenhouse gas (GHG) emissions, has begun to realize its essential role in improving the environment by reducing emissions through the life cycle of buildings and infrastructure. In the meanwhile, despite conflicting scientific evidence as to the severity of GHG emissions' impact on climate change, the insurance industry has more of an incentive than any other industry to catalyze upon global action to promote sustainability. In the long term, these strategies could help mitigate the risk of catastrophic natural hazards that would affect many insurance lines, including property and casualty, business interruption, health, and life. Although green insurance is a relatively new concept, first started in 2006 by Fireman's Fund, insurance companies have provided a variety of products or services covering renewable energy, energy efficiency, and green buildings, either new or upgrades of existing buildings to a more resilient status following a loss. However, with government entities seeking to launch incentive-based regulations and bidding standards for reducing carbon footprints, insuring against the risk of discrepancy between the actual and expected performance of GHG emissions during construction is another aspect that is often overlooked. Drawing an analogy from the construction professional liability insurance, I explore the possibility of introducing

emissions liability insurance, an innovative insurance product designed to manage embodied carbon in the building process. The following sections initially elaborates on the role of insurance in sustainability risk management and follows this with an investigation on the Insurability of GHG Emissions Liability. Finally, a conceptual model is presented to illustrate how to utilize emissions liability insurance to guarantee the performance of GHG emissions during the construction phase.

### ***Introduction***

Burdened with a stressed budget and tight schedule, most development in the construction industry in the past was mainly guided by short-term economic considerations (Singh 2007). However, the imperative is a strong focus to deal with the pressing issues of sustainability at each stage of a building's life cycle. In response to other industries that strive to improve their environmental performance, the construction community has recently begun to realize its leadership role in promoting environmental stewardship. While a considerable amount of prior research has been devoted to assess the environmental impacts of sustainable design alternatives and post-construction operations (Vale and Vale 1996, Guggemos and Horvath 2006, Peschiera et al. 2010), there is an increased awareness of, and demand for, managing greenhouse gas (GHG) emissions during the building process. According to the EPA (2009a), the construction industry produced approximately 1.7% of the total U.S. GHG emissions in 2002, placing itself as the third highest GHG emitting sector. Although a single construction process does not produce as much GHGs as the operations of other industries, such as chemical or steel manufacturing, the sheer number of construction projects results in a significant amount of aggregate emissions (EPA 2009a). Further projections illustrate that among

seven industrial sectors, the construction industry is predicted to have the highest average annual rate of increase in GHG emissions from 2011 through 2030 (EPA 2009a).

Although it is difficult to determine the extent of climate change driven by the GHG effect, there is little scientific debate on the fact that the global concentration of CO<sub>2</sub> in the atmosphere has far exceeded its natural range (EIA 2004). As a result of global warming, the Earth is experiencing surface temperature increases, as well as changes in rainfall patterns, snow and ice cover, and sea levels (EPA 2009b). Extreme weather events, such as floods, droughts, heat waves and wildfire, also show a consistent trend of an increase in frequency and intensity from 1950 to 2000 (IPCC 2007). In 2005, catastrophic losses to the economy were \$62 billion, up from an average of \$4 billion a year in the 1950s and \$40 billion in the 1990s (ISO 2007). Moreover, climate change could also impose profound threats to human health (Epstein 2000). The WHO estimates annual deaths of 150,000 from climate change as of 2000 (McMichael et al. 2003). According to Epstein (2000), global warming will expand the incidence and distribution of many serious medical disorders. Undoubtedly, global warming and climate change has presented itself as one of the most significant risks that could lead to serious social and economic consequences.

As the second largest industry in the world in terms of assets, the insurance industry has long been in the vanguard of understanding and managing risks and has more of an incentive than any other industry to catalyze upon global action to promote sustainability and address the environmental challenge of climate change (UNEP 2009). Although green insurance is a relatively new concept, first started in 2006 by a U.S. insurance company Fireman's Fund, insurance companies have provided more than 600



innovative products or services covering renewable energy, energy efficiency, green buildings, either new or upgrades of existing buildings to a more resilient status following a loss (Bushnell 2010). However, with government entities seeking to launch incentive-based regulations and bidding standards for reducing carbon footprints, insuring against the risk of discrepancy between the actual and expected performance of GHG emissions during construction is another aspect that is often overlooked. This research will focus on the application of emissions liability insurance in managing embodied carbon in the building process. Drawing an analogy from the mechanism of the construction professional liability insurance, this innovative insurance product will serve as a financial tool to support the government's effort in promoting sustainability by guaranteeing that the contractor will perform in accordance with the terms and conditions of an underlying agreement of a carbon footprint limit during the construction phase.

### ***Problem Statement***

The key problem with current practices in managing GHG emissions in the construction phase is that existing government regulations and standards for construction emissions are limited to hazardous air pollutants (HAPs), such as CO, NO<sub>x</sub>, PM, volatile organic compound (VOC) and SO<sub>2</sub>, with no focus on GHGs (Peña-Mora et al. 2009), despite the fact that GHGs are also defined as a pollutant under the Clean Air Act, ruled by the U.S. Supreme Court in 2008 (EPA 2008). As a result, although the government is providing incentives for carbon reduction, there are no enforcement mechanisms to guarantee the performance of GHG emissions if the contractors consider the reduction measurements to be economically unattractive. On the other hand, even if contractors strive to follow the pre-determined emissions goal, there always exists the risk of "over-emissions" resulting

from inefficient construction methods, field rework, improperly sized equipment, among others. To deal with this unwanted situation, there is a broad agreement that the key policy is to put a price on GHG emissions (CBO 2008). One example is the popular cap-and-trade policy in Europe and Asia, where each firm in the system is assigned an overall quota, or cap, on the total amount of CO<sub>2</sub> they are allowed to emit. Firms that "over-emit" must purchase an extra quota from those organizations that emit less than their allowance, so as to keep the total amount of emissions in the system to a certain limit (Tietenberg 2003). However, despite the vigorous debate of introducing the cap-and-trade program into the US, there is currently no system in existence. Hence, there is a need to explore other possible methods on managing GHG emissions during the construction phase.

In this research, one approach is proposed which adds another dimension to the traditional project management structure and investigates the possibility of applying insurance theories into construction GHG emissions. As illustrated in Figure 21, contractors will suffer economic consequences if they fail to follow the planned schedule, budget and quality described in the contract. For example, the owner requires a performance bond from the contractor as protection from financial loss should the contractor fail to fulfill the contract (Dagostino and Feigenbaum 1999); a liquidated damage clause would protect the owners from construction delays by charging the contractor a certain sum of money for every day he/she goes over the scheduled completion date (Eggleston 2009). Analogously, required emissions liability insurance will compensate the owner in the event of the contractor failing to meet the emissions goal, as promised in the contract.

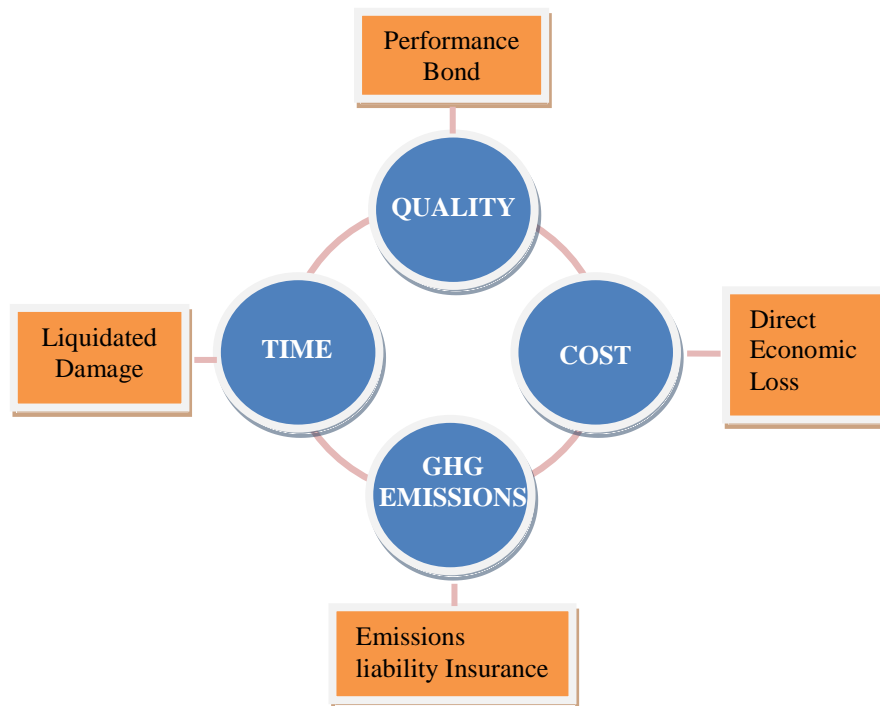


Figure 21: Project Management Structure With GHG Emissions

### ***The Role Of Insurance In Sustainability Risk Management***

The previously mentioned issues with current construction GHG emissions management also indicates vast opportunities for insurers to be part of the global warming solution. In risk management, insurance products have served as both risk control and risk financing techniques. The first function is designed to eliminate or reduce the likelihood or amount of a loss (Myhr and Markman 2003). For example, as part of most health insurance plans, routine visits to a doctor's office or periodic physicals provide ways to reduce the likelihood of getting sick. Similarly, having emissions liability insurance on a project would encourage contractors to closely monitor their emissions status and implement an adjustment in a timely fashion; secondly, as a risk financing technique, an insurance product also provides a means to pay for losses that occur (Myhr and Markman 2003).

Again, taking health insurance as an example, the insurance company will compensate customers for their medical expenses, wholly or partially, in return for the payment of a specified premium. In construction GHG emissions, especially for public projects, by requiring emissions liability insurance from the awarding contractor, the owner would expect compensation from the insurance company for the negative environmental impact of over-emissions, should the contractor fail to meet the pre-determined emissions goal. In addition, analogous to auto insurance, in which the insurance company charges a higher premium to drivers with a higher likelihood of incurring accidents or reject to insure drivers with bad records, the emissions liability insurance could serve as a selection tool in the bidding process that screens out contractors with undesired environmental performance by a high emissions liability premium.

In addition to providing financial protection for owners in managing GHG emissions and helping to promote sustainability in the construction process, developing an innovative insurance product for GHG emissions could also be a good business opportunity for the insurance industry. Prior research studies have provided a number of approaches for reducing GHG emissions during the construction process, both from the owner's and contractor's perspectives. For example, the contractors are able to control activities, such as fuel selection, equipment selection, equipment idling time, and materials recycling, while the owner has an influence over site selection and materials selection. Table 9 is a summary of the measurements suggested by EPA (2009a).

Table 9: Opportunities To Reduce Emissions

Methods		Details	Owner's influence	Contractor's influence
Reducing Fuel Use	Fuel Selection			•
	Reduced Idling			•

	Equipment Maintenance	•	
	Driver Training	•	
	Properly Sized Equipment	•	
	Replaced or Repowered Equipment	•	
	Bio fuels for Trucks and Non-road Equipment	•	
	Alternatives to Diesel Generators	•	
	Employee Commuting	•	
Conserving Electricity	Reducing Field Electricity Use	•	
	Reducing Office Electricity Use	•	•
Reducing Impacts of Construction Materials	Recycling and Reuse		•
	Materials Selection, Procurement, and Shipment Methods	•	

These measures would effectively reduce loss exposures, which are similar to the more familiar risk management technologies that encouraged insurance company's involvement, such as automobile seatbelts or airbags, smoke alarms, or preventive medicine (Mills 2003).

In addition, the increasingly competitive market motivates insurance and risk-management companies to push for product and service innovations that differentiate them from fellow competitors and offer new ways to meet customers' demands (Mills 2003). For example, Fireman's Fund's GreenGuard Program replaces standard materials and systems with green alternatives after a loss. AIG's Sustain-A-Build Program enables AIG environmental customers to receive discounts of up to 10% on premiums for new pollution legal liability policies. These two programs are both pilot insurance programs entering the fledgling construction sustainability risk management market (Ayers 2008).

### ***Emissions Liability Insurance***

Not all risks are insurable by private insurers (Pritchett et al. 1996). A risk that is perfectly suited for insurance would meet six ideal requisites: 1. It must have a large

number of similar exposure units; 2. The claims must be derived from a fortuitous loss outside the control of the principal; 3. The losses should be definite; 4. It must have a determinable probability distribution; 5. It must be catastrophe unlikely; and lastly, 6. It must be economically feasible (Pritchett et al. 1996). Table 10 elaborates upon the insurability of GHG emissions liability in construction projects.

Table 10: Insurability Of GHG Emissions Liability

Requisite Characteristics For Insurability	GHG Emissions Liability
Large number of similar exposure units	More than 800,000 construction firms and the even larger number of construction sites form a massive emissions liability risk pool (EPA 2009).
Accidental loss	The performance of GHG emissions is subject to many factors, such as work efficiency, equipment condition among others. Because of the uniqueness of each project, the risk of over-emissions involves only the possibility, not the certainty.
Definite loss	Require detailed contract provisions regarding recordkeeping for GHG emissions for future reference of cause and severity.
Calculable loss	The loss could be evaluated by the price per unit of GHG emissions (generally one ton) as in the emissions cap and trade market.
Limited risk of catastrophically large losses	Catastrophic refers to an event that would affect many insured at the same time, such as hurricanes or earthquakes, which is hardly the case with GHG emissions.
Affordable premiums	The ratemaking process of determining the premium should be based on statistical data and empirical experience

Figure 22 shows the mechanism of the emissions liability insurance. First, the owner sends out an RFP with an estimated limit of GHG emissions for a certain project. Contractors then submit proposals with quotes of their emissions liability insurance, determined by the insurance company's underwriting process, and denotes for what amount of insurance, at what price, and under what conditions. The premium of the GHG emissions liability is part of the cost estimates, similar to the performance bond. The owner evaluates the bids accordingly and monitors the awarding contractor's emissions performance after he/she enters the construction phase. At the end of the project, if the contractor emits less GHG than the setting limit, the insurance company may offer future premium discounts for his/her emissions liability insurance. In contrast, the insurance company could charge a higher premium if the contractor "over-emits", making him/her less favorable in future competitions.

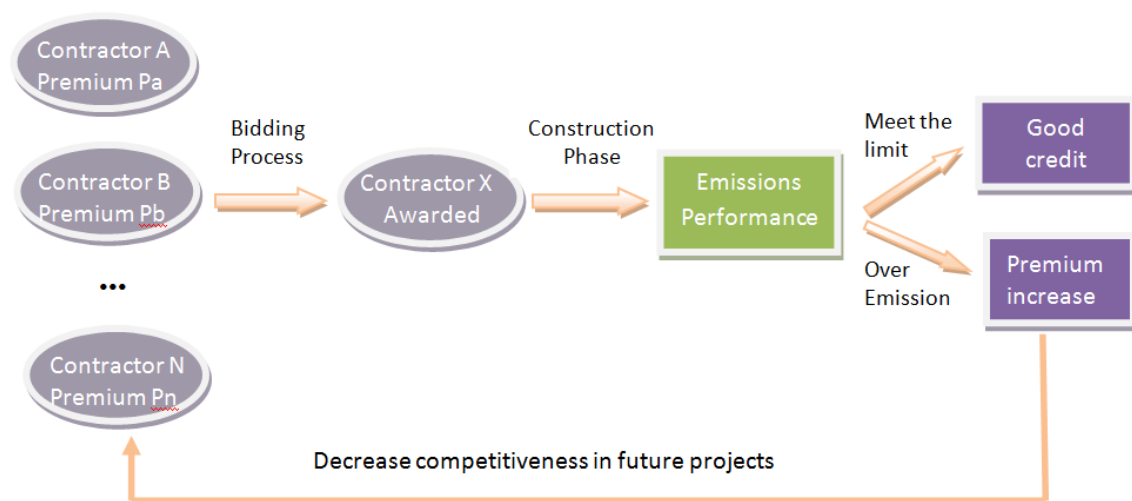


Figure 22: GHG Emissions Liability Insurance Model

### Conclusions

Just as the insurance industry once asserted its leadership and expertise in tackling fire and seismic risks, the prospect for its involvement in managing GHG emissions as a

financial tool during the building process stands as an immense opportunity for promoting sustainability in construction projects. This paper introduces the concept of developing an innovative insurance product – emissions liability insurance. From the owner's perspective, the objective is to encourage construction contractors to improve their environmental performance in public projects through a financial means. Although the model presented in the paper is still in the conceptual development phase, it appears that there are both risk management and risk financing benefits potentially available to owners if such a process can be devised.

While this paper has provided a framework for emissions liability insurance, the details of how to use it directly in a construction project still need to be developed. Furthermore, the authors will look into other possible applications of insurance, such as cap and trade, general contractor's pollution liability, and so on, under the framework of construction sustainability risk management.



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## APPENDIX A: Dispute Distribution Simulation In Chapter 2

```

function [ ] = Dispute( )
%first journal paper

for i = 1:100
T = 24;
lambda = 3;
U1 = rand();
t = -(1/lambda)*log(U1);
stop = 0;
C = [];
S = [];
p1 = 0.5;
p2 = 0.25;
p3 = 0.175;
p4 = 0.075;
c1 = 0.015;
c2 = 0.0525;
c3 = 0.165;
c4 = 0.805;

while stop==0
U2 = rand();
if U2<=p1
    c = c1;
    s = c1+1880*(exp(0.007*c1)-1);
elseif U2>p1 && U2<= p1+p2
    c = c2;
    s = c2+1880*(exp(0.007*c2)-1);
elseif U2>p1+p2 && U2<=p1+p2+p3
    c = c3;
    s = c3+1880*(exp(0.007*c3)-1);
else
    c = c4;
    s = c4+1880*(exp(0.007*c4)-1);

end
C = [C;c];
S = [S;s];
U1 = rand();
t = t -(1/lambda)*log(U1);
if t > T
    stop = 1;
end

end

Totalloss(i) = sum (C);
Totalsub(i) = sum (S);
GP(i)= Totalloss(i) * 1.25;
end
TL = mean(Totalloss)
TS = mean(Totalsub)
TGP = mean(GP)

```

```

end

function Tt = nhPoisson(t)

% This program generates the next arrival of a non homogeneous Poisson
% process that occurs after time t.

Stop = 0; % Indicates whether we successfully generated the next
arrival or not
[lambda, lambdat] = getRate(t); % Obtain the value of lambda
while Stop == 0
    U1 = rand;
    t = t - log(U1)/lambda;
    [lambda, lambdat] = getRate(t); % Obtain the intensity function
    lambda(t)
    U2 = rand;
    if U2 <= lambdat/lambda
        Tt = t;
        Stop = 1;
    end
end
end
end

```

## APPENDIX B: Dispute Distribution Simulation In Chapter 3

```

function [ ] = ADRInsurance( )
%second journal paper

for i = 1:100
L = 24;
lambda = 2;
U1 = rand();
t = -(1/lambda)*log(U1);
stop = 0;
C = [];
S = [];
T = [];
T = [T;t];
p1 = 0.5;
p2 = 0.25;
p3 = 0.25;

mu1 = 0.015;
sigma1 = (0.5 * mu1)^.5;
mu2 = 0.015;
sigma2 = (0.5 * mu2)^.5;
mu3 = 0.045;
sigma3 = (0.5 * mu3)^.5;

while stop==0
U2 = rand();
if U2<=p1
    temp = normrnd(mu1,sigma1);           %truncated normal
    I = 0;
    while I == 0
        if temp >= 0 && temp <= 0.03
            I = 1;
        else
            temp = normrnd(mu1,sigma1);
            I = 0;
        end
    end
    c = temp;
    s = c+1880*(exp(0.007*c)-1);

elseif U2>p1 && U2<= p1+p2

    temp = normrnd(mu2,sigma2);           %truncated normal
    I = 0;
    while I == 0
        if temp >= 0 && temp <= 0.03
            I = 1;
        else
            temp = normrnd(mu2,sigma2);
            I = 0;
        end
    end
    c = temp;
    s = c+1880*(exp(0.007*c)-1);

elseif U2>p1+p2 && U2<= p1+p2+p3
    temp = normrnd(mu3,sigma3);           %truncated normal
    I = 0;
    while I == 0
        if temp >= 0 && temp <= 0.03
            I = 1;
        else
            temp = normrnd(mu3,sigma3);
            I = 0;
        end
    end
    c = temp;
    s = c+1880*(exp(0.007*c)-1);
end
end

```

```

        end
    end
    c = 0.03 + temp;
    s = c+1880*(exp(0.007*c)-1);
else
    temp = normrnd(mu3,sigma3);           %truncated normal
    I = 0;
    while I == 0
        if temp >= 0 && temp <= 0.09
            I = 1;
        else
            temp = normrnd(mu3,sigma3);
            I = 0;
        end
    end
    c = 0.06 + temp;
    s = c+1880*(exp(0.007*c)-1);

end
C = [C;c];
S = [S;s];
U1 = rand();
t = t -(1/lambda)*log(U1);
T = [T;t];
if t > L
    stop = 1;
end

end

Totalloss(i) = sum (C);
Totalsub(i) = sum (S);
GP(i)= Totalloss(i) * 1.25;

Insured_nosub(i) = 0.05*Totalloss(i) + max(0,(Totalloss(i)-3));
sub = (Totalloss(i)-3)+1880*(exp(0.007*(Totalloss(i)-3))-1);
Insured_sub(i) = 0.05*Totalsub(i) + max (0,sub);
if Totalloss(i)>3
    In_Comp(i) = 3*0.95;
else
    In_Comp(i) = Totalloss(i)*0.95;

end
end

TL = mean(Totalloss)
TS = mean(Totalsub)
TGP = mean(GP);
TINS = mean(Insured_nosub)
TIS = mean(Insured_sub)
TI = mean(In_Comp)

dfittool(Totalloss)
dfittool(Totalsub)
dfittool(Insured_nosub)

```



```
dffittool(Insured_sub)  
dffittool(In_Comp)  
end
```

## **AUTHOR'S BIOGRAPHY**

Xinyi Song was born in Leshan, China. She graduated with honors from Tsinghua University in Beijing with a Bachelor of Science in Civil Engineering in 2007. After graduation, she continued to pursue graduate education and completed a Master of Science in Civil Engineering at the University of Illinois at Urbana-Champaign in 2009. She then moved to New York City and completed a PhD in Civil Engineering with focus on Construction Engineering and Management from Columbia University in 2012. After earning her PhD, Xinyi will begin work for the Georgia Institute of Technology as an Assistant Professor in the School of Building Construction under the College of Architecture.